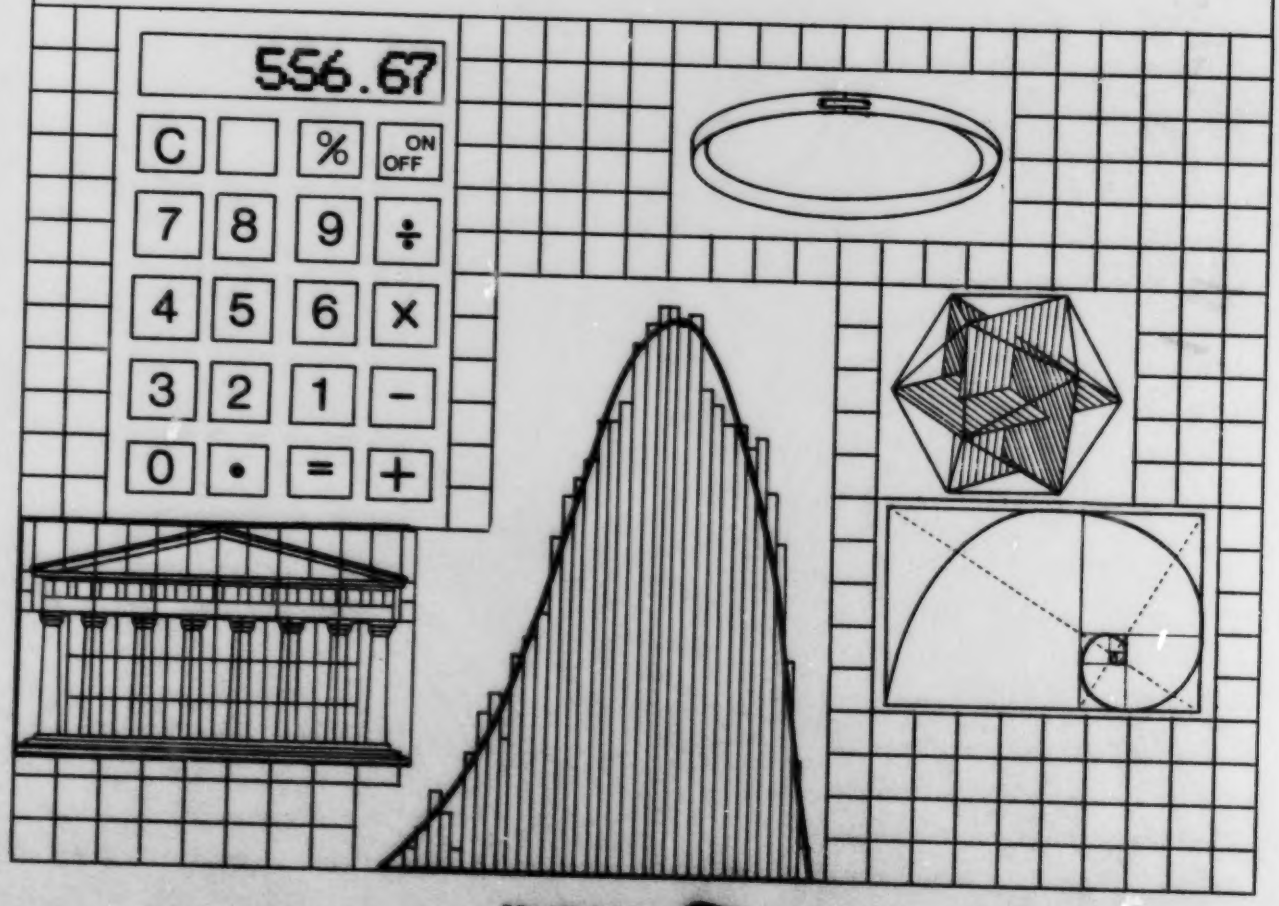
MATHEMATICS ASSESSMENT

ENGLISH LANGUAGE AND FRENCH IMMERSION PROGRAMS

1987

FINAL REPORT



Manitoba Education

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MATHEMATICS ASSESSMENT 1987

FINAL REPORT

ENGLISH LANGUAGE AND FRENCH IMMERSION

A REPORT OF THE

CURRICULUM DEVELOPMENT AND IMPLEMENTATION BRANCH

MANITOBA EDUCATION

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PREFACE

This report contains a description and analysis, along with conclusions and recommendations, of the three components of the 1987 Mathematics Assessment:

- The student achievement tests at grades 3, 6, 9, and 12.
- The comparison testing (1981-1986) at the same grade levels.
- The Teacher Survey.

There are two other reports on this assessment. The first one: Mathematics Assessment Program 1987 - Preliminary Report, presents individual item and subtest data on each of the tests. The other one: Mathematics Assessment Program 1987 - Summary Report is an abridgment of this Final Report. Both the Preliminary and Summary reports are distributed widely to schools, school division offices, to teacher and trustee organizations, as well as to libraries and universities. This Final Report will be distributed only to school division offices, teacher and trustee organizations libraries, and universities. Copies of this report may be obtained from Manitoba Education.

A Technical Advisory Committee of teachers and other educators developed the recommendations in this report. These recommendations are based upon an analysis of the data collected and upon the judgment of the members of the Technical Advisory Committee in the light of their considerable knowledge and experience. Educators are encouraged to review these reports for applicability to their programs.

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This assessment would not have been possible without assistance from the many people involved in the development of the tests and the production of reports. The co-operation of the students who wrote the tests and the teachers of these students was also very important to this assessment. Special mention must be made of a number of groups.

- The contract team who gave professional assistance in every phase of the project.
- The Joint Committee on Evaluation which provided guidance throughout the program.
- The Mathematics Technical Advisory Committee which advised on test production and analysis of results.
- The teachers and others who participated in the review of the objectives.
- The school administrators, teachers, and students who were involved in the pilot-testing.
- The teachers who participated in the teacher surveys.
- The divisions and schools that released their teachers to assist in the program.
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CHAPTER I

OVERVIEW AND HIGHLIGHTS OF THE MATHEMATICS ASSESSMENT 1987

The major portion of the assessment of mathematics at grades 3, 6, 9, and 12 was carried out in the late spring of 1987. This was the second such assessment; the first was done in 1981.

The total assessment program consisted of three components:

1. an assessment of the prescribed curriculum learned by students.

2. a comparison of student performance in 1986 with that of 1981.

3. a survey of teachers.

1. In the first component, the sampling design for the grades 3 and 6 testing involved approximately 10% of the students in each public school classroom. The designs for grades 9 and 12 testing were based on public schools as units; that is, all students enrolled in the mathematics courses in the spring term within the selected schools were requested to write the tests.

   Schools were given the option of requesting tests for all their students in the 1987 assessment. In addition, scoring services were provided by the Department. Tests were actually requested by teachers, schools, or school divisions for more than 90% of students in grades 3 and 6, 70% of students in grade 9, 87% of students in Mathematics 300 and 65% of students in Mathematics 301.

2. The second component, a comparison of student performance in 1986 with 1981, involved a sample of students at grade levels 3, 6, 9, and 12. Students wrote the same tests in 1986 that students wrote five years earlier. At the grade 12 level this included a general test independent of any course and was written by a sample of all grade 12 students. In addition to this general test, mathematics 300 students wrote the 1981 mathematics 300 test, although some questions were deleted due to curriculum changes since 1981. Mathematics 301 was not tested because of changes in the curriculum.

3. A Survey of Teachers - a questionnaire was sent to a sample of teachers at each of the four grade levels. It dealt with demographic information; teaching and evaluation practices; use of calculators and computers; and teachers' views on certain curriculum issues.

Mathematics Programs

The Manitoba mathematics program consists of a large number of skills and concepts categorized into major topic areas. For grades 3 and 6, the following topics were delineated:

Number systems, operations, and properties--using properties and performing operations with numbers.

Measurement--using the appropriate measures in the metric system and determining such things as length, area, volume, and capacity.

Geometry--recognizing shapes, vocabulary, and using notions of position and angle.

Graphing--constructing and interpreting graphs.

Problem solving--including both routine and nonroutine problems.

At the 9 and 12 levels the topic areas are course specific and based upon the respective curriculum guides. Each of these courses has a required core of topics and a selection from a set of option topics.

GRADE 9

Core	Options
Real Number System	Algebra
Construction Geometry	Consumer-Related Topics
Open Expressions	Coordinate Graphing
Equations	Statistics
Word Problems (routine)	Geometry
Problem Solving (nonroutine)	

MATHEMATICS 300

Core	Options
Polynomial & Rational Functions	Binomial Theorem
Circular Functions	Compound Interest
Analytic Geometry	Sinusoidal Functions
Exponents and Logarithms	Circular Functions
Sequence and Series	Permutations and Combinations
	Conic Sections
	Transformations of Conics

MATHEMATICS 301

Core	Options
Consumer Mathematics	Annuities
Algebra	Depreciation and Distribution of Overhead Costs
Trigonometry	Digital Logic
Statistics	Investments
	Interpretation of Graphs
	Quadratic Equations
	Permutations and Combinations
	Statistics

Summary of Assessment Procedures

The assessment process began with the identification of grade levels to be assessed and test topics. For grades 3, 6, and 9, the tests were based on objectives identified as important by teachers throughout Manitoba at those grade levels for the first cycle of mathematics assessment in 1981. At the grade 12 level curricula for both of the courses have changed since the 1981 Assessment; therefore, a new set of objectives based on the new Guides was identified. A questionnaire, containing these objectives, was sent to all high school mathematics department heads in mathematics. They were asked to rate the objectives as to their importance for assessment.

The tests were developed during 1986 and 1987 and were administered in late May and in June of 1987. The results for the provincial sample were reported in the Preliminary Report in November, 1987. Interpretations of the data were provided by the Technical Advisory Committee augmented by additional teachers from the respective grade levels.

The Final Report contains a summary of results, interpretations, and conclusions at each grade level. In addition summaries are provided of results of the comparison testing and the teacher survey. As well, it includes the conclusions and recommendations based on all the results.

Major Findings of the Student Assessment

Grade 3

Overall performance was satisfactory. Place value and basic operations with whole numbers were well done. Weaknesses were apparent in problem solving and estimation. Performance in measurement, geometry, and graphing were considered satisfactory. Work with fractions continues to be an area of some difficulty. Results in the comparison testing indicate approximately equivalent performances overall. However, declines were noted in applications, fractions, and decimals - areas indicated as unsatisfactory in 1981.

Grade 6

Computation with whole numbers, including application in word problems was well done, but operations and applications with fractions and decimals was a weak area. Computational estimation appears to be poorly understood. Performances in measurement, geometry, and graphing were all considered satisfactory. Performance was low in nonroutine problem solving but was not considered unsatisfactory by the TAC because of the nature of and the recent emphasis in that area. Overall performance in the comparison testing in 1986 was somewhat lower than in 1981.

Grade 9

Performance in each of the grade 9 core areas was considered satisfactory. A number of specific concerns were noted by the Technical Advisory Committee, among them the need to stress the continued importance of estimation and problem solving. Grade 9 classes were to select two out of five option topics. Almost all classes elected the algebra option as one of the two. Performance in word problems was lower in 1986 than it was in 1981.

Grade 12

Mathematics 300. The results were considered by the Technical Advisory Committee to be unsatisfactory. Among the core areas, only parts of Analytic Geometry and some algebraic items were satisfactory. Unsatisfactory were: circular functions; Exponents and Logarithms, Sequences and Series; and all option topics. The comparison testing, which showing slight gains in two areas, indicated declines of some concern in three areas.

Mathematics 301. Overall performance was considered satisfactory in the core areas with only a few exceptions in Algebra and Trigonometry. Among the optional topics, Interpretation of Graphs was well done, but weaknesses were evident in Investments, Quadratic Equations, Statistics, and Permutations and Combinations.

General Test. The same general mathematics test was administered in 1981 and 1986 to Mathematics 300 and 301 students as well as to students who had not taken any grade 12 mathematics courses. Performance declined in all areas for all groups.

The Teacher Survey

Grades 3 and 6

The organizational aspects of teaching at these grade levels has changed little since the 1981 survey. Most teachers teach in single grade, self-contained classrooms. Individual, small and large-group instruction are all used. Concrete materials appear to be widely employed, but their use decreases at the higher grade level. Calculators are used in limited ways at both grade levels, but explicit instruction in their use is infrequent. Textbooks with accompanying guides, the Manitoba Curriculum Guide, and supplementary materials from Manitoba Education are widely used. Teachers indicated a number of areas in which professional development activity is desired.

Grade 9

A single grade classroom is the norm for grade 9 classes, with about half of these heterogeneously grouped. Only about one-half (down from 60% in 1981) of grade 9 teachers have at least half of their teaching load in mathematics. Furthermore, one-half of the grade 9 mathematics teachers have two or fewer university courses in mathematics; 25% have none. Total group instruction is used daily in most classrooms and the majority of teachers follow a single textbook. Calculators are used frequently, but computers seldom. The Curriculum Guide is widely used as are materials from inservice programs. Teachers indicated several areas in which they desired further professional development.

Grade 12

Most grade 12 mathematics teachers have had teaching experience at both junior and senior high levels and teach courses in both the "00" and "01"

streams. About one-half of them teach mathematics full time and over 75% teach mathematics 60% time or more. Lecture and demonstration are the dominant instructional modes with little use of concrete materials or computers, although calculators are widely used.

Teachers in both courses teach parts of the option topics without strict adherence to structure provided in the Curriculum Guide. The majority of Mathematics 301 teachers felt that options should be retained in Mathematics 301, but one-half of the Mathematics 300 teachers felt that the entire Mathematics 300 course should be compulsory.

Teachers expressed the view, even more strongly than in 1981, that less mathematics learning is taking place in the semester system than in the full-year system.

Summary of Recommendations

The recommendations from the Technical Advisory Committee arose from a synthesis of student results and the teacher survey. They are listed in full in Chapter IX of this report. A summary is provided below.

Grades 3 and 6

- That guidelines for the use of calculators be included in any future elementary mathematics curriculum guide and that calculators be used in the mathematics program where appropriate.
- That problem solving become an integral part of the curriculum and of mathematics programs in classrooms at all levels.
- That teachers be provided with appropriate materials and training to teach measurement.
- That professional development be provided in the areas of need indicated by teachers.
- That mathematics be taught <u>at least</u> the recommended number of minutes per day (i.e., 45).
- That greater attention be focussed on the teaching of concepts.
- That concrete materials be used in the introduction and maintenance of concepts and skill development.
- That particular attention be paid to the transition from concrete manipulation to symbolic recording of students' work.
- That more attention be paid to estimation in numerical computation, rounding off, and the relationship between them.
- That work with decimals, both computationally and conceptually, be given increased emphasis.
- That work with fractions, both conceptually and computationally, be given greater emphasis.

Grade 9

- That problem solving strategies continue to be integrated into the curriculum, and where appropriate, professional development be provided.
- That consideration be given for the inclusion of the Algebra option as a core topic for all students.
- That estimation be given greater emphasis in the curriculum.
- That work with calculators and computers become an integral part of the grade 9 curriculum.
- That inservice programs be organized on the appropriate use of the calculator and computer.
- That inservice programs in the teaching of introductory algebra with emphasis on the use of concrete materials be organized.
- That grade 9 teachers have adequate background for their teaching assignments.
- That upgrading or refresher courses be provided for teachers of junior high mathematics.

Grade 12

- That the Mathematics 301 option topics be reassessed to determine whether that part of the curriculum should be revised.
- That the counselling of students in Mathematics 300 be examined to determine the reasons students are taking this course.
- That the core/option format of Mathematics 300 and the designation of particular topics as "options" be examined.
- That sufficient time be made available so that teachers are able to teach the entire curriculum.
- That every effort be made to increase students' mathematical vocabulary by constantly using correct terminology and notation.
- That the use of transformations as a foundational concept in the development of relations and functions be emphasized throughout the Mathematics 300 course.
- That consideration be given to making Mathematics 301 the mathematics admission requirement to post-secondary programs not requiring the specific content of Mathematics 300.
- That Mathematics 301 credits not be given to students who have been enrolled in Mathematics 300 and who, for some reason, will not be given credits for Mathematics 300.

- That the Student Academic Record System be developed and maintained in such a way that analysis over time can be made.

- That professional development needs of high school mathematics teachers be determined and provided for.

- That the issue of low performance at the Mathematics 300 level be studied and that strategies be implemented which redress this problem.

- That the issue of the low general arithmetic skills of the grade 12 students be reviewed and that strategies be implemented which redress this problem.

CHAPTER II

THE MATHEMATICS ASSESSMENT PROGRAM

An assessment program involves a number of distinct tasks, not the least of which is the reporting of the results. It is intended that the results and the consequent recommendations be studied by classroom teachers to review their programs, by those responsible for professional development to provide needed inservice opportunities, by Manitoba Education to review and revise the mathematics curricula, and by any other parties interested in the improvement of mathematics education for all students at all levels.

Format of the Reports

The first chapter of this, the Final Report, provides a brief overview of the assessment procedures, findings, and recommendations. This material is a distillation of what follows in the remainder of the report, namely: student results and their interpretation by grade level, results from the Teacher Survey, and conclusions and recommendations.

Item and subtest mean data on the student results for the 1987 test administration were published previously without interpretation in the Manitoba Mathematics Assessment Program 1987: Preliminary Report. Data from the 1981-1986 comparison and from the teacher survey are not included in the Preliminary Report. Subtest data from the comparison tests and individual question data from the teacher surveys are reported in this Final Report. The findings from all of these components of the program have been reviewed by the Contract Team and by the Technical Advisory Committee augmented by teachers at each of the assessed grade levels. The views of these groups have been incorporated into the summary presentation of results and interpretations found in this document. All results have been reported on a provincial basis only, with no identification of individuals, schools, or school divisions.

Background to the Assessment

The Mathematics Assessment Program is part of the overall Manitoba assessment program as recommended by the Joint Committee on Evaluation and approved by the Minister of Education. The purposes for the program are:

1. To provide benchmark indicators about the level of student achievement in the Province of Manitoba.

2. To obtain data on student achievement that will assist in curriculum and program improvement at the provincial and local levels.

3. To assist school divisions in student and system evaluation.

4. To help teachers improve their evaluation skills.

The student achievement data collected in the mathematics program reflects an "everyday" level of performance as opposed to an optimum level. It is thus a snapshot of average student performance for which no test preparation was made by students. From a curricular perspective this provides a measure of the extent to which the provincial curriculum is being learned.

Mathematics Topics

The mathematics tests were designed to assess the kinds of understanding, skills, and knowledge that are promoted in the Manitoba curriculum and that were given priority for assessment by Manitoba teachers. Tests were developed at the grade 3, 6, 9, and 12 levels. On the basis of samples of students from public schools throughout Manitoba, student performance was determined on the objectives identified for assessment. The topic areas assessed are listed in Chapter I and in each of the chapters giving grade level results.

Single tests were developed for grades 3, 6, and 9 respectively. The test for grade 9 contained provision for the core topics and the selection of option topics as described in the curriculum guide. At the grade 12 level, two tests were developed, one each for Mathematics 300 and Mathematics 301. Both of these tests contained core and option sections based on the current guide.

Assessment Procedures

The procedures used in the Mathematics Assessment Program are similar to those used in the other subject areas. Following the designation of mathematics as an area to be assessed in 1987, a Mathematics Technical Advisory Committee (TAC) and a Mathematics Contract Team were established to assist in the actual development of tests and reporting of results.

The TAC members were teachers who represented English language, French immersion, and Français schools. The subcommittees at each grade level consisted of four classroom teachers and a member of the Contract Team familiar with the level. One person from the Assessment Section of the Curriculum Development and Implementation Branch, Manitoba Education served as chairman of the TAC. Manitoba Education curriculum staff acted as consultants to the TAC.

The Mathematics Contract Team consisted of one university mathematics education specialist acting as coordinator and four classroom teachers of mathematics.

The major steps involved in the Assessment Program are outlined below.

Step 1: Identification of Objectives

The curricula at the grade 3, 6, and 9 levels have remained unchanged since the last assessment in 1981. Thus the set of objectives from which the committees worked was not altered except for the addition of problem solving objectives. These were added to reflect the emphasis that problem solving

has received in position statements from the National Council of Teachers of Mathematics, in current mathematics education literature and, most importantly, in professional development work on this topic over the last several years.

New curricula have recently been implemented in the high school program. Objectives from these new curricula in Mathematics 300 and 301 were identified for assessment purposes.

Step 2: Selection of Objectives for Testing

At the three lower grade levels, the objectives rated as important for assessment by teachers across the province in 1981 were used again as the basis for test development. In addition, as noted above, problem solving was included. For each of the grade 12 courses, the objectives were sent to all high school mathematics department heads throughout Manitoba. The teachers were asked to rate these objectives as to their importance for assessment. This rating provided the basis for developing the Mathematics 300 and 301 tests.

Step 3: Production of Test Items

The TAC recommended the format and the specifications for the tests. The Contract Team, with the assistance of the TAC, produced test items according to the specifications. The Contract Team was also guided by the need to produce items at various cognitive levels.

The test items were reviewed, and in some cases modified, by the TAC before inclusion in the pilot tests. This was done to ensure accuracy of the wording, appropriate readability, and technical quality of the items.

Step 4: Pilot Testing

For each level of testing, two pilot tests were developed and administered to classes at each grade level. For the lower three levels, the pilot testing was carried out at the end of May in 1986. At the grade 12 level, students wrote the pilot tests at the end of the first semester in January, 1987.

The results of the pilot tests were analyzed to determine the adequacy of the test items. Items were deleted or modified as necessary by the TAC and rewritten by the Contract Team. The final versions of the tests were reviewed and edited by the TAC.

Step 5: Provincial Administration of Tests

Tests were administered to students in the provincial sample in late May and in June. Students were the sampling units in grades 3 and 6 while schools were sampling units in grades 9 and 12. The reason that schools were sampling units was that it was necessary to contact schools directly due to the complexity introduced by testing the option sections of the mathematics programs in these grades. Schools were selected on a stratified random basis. Specific sampling data are provided in Table II-1.

Teachers, schools, or school divisions could request copies of the tests for their own use. Test scoring for these groups was done locally or through Manitoba Education. Such results were returned directly to schools or divisions and were not part of the sample analyzed in the Assessment Program. Indeed, the local choice to test beyond the sample, provided teachers and schools the opportunity to analyze their own results along with provincial findings. Tests were requested by teachers, schools, or school divisions for more than 90% of students in grades 3 and 6, 70% of students in grade 9, 87% of students in Mathematics 300, and 65% of students in Mathematics 301.

TABLE II-1

The Provincial Sample: 1987 Mathematics Assessment

Grade/Level	Population		Number in Sample		Percent of Population	
	Students	Schools	Students	Schools	Students	Schools
3	13 935	-	1282	-	9.2%	-
6	14 492	-	1391	-	9.6	-
9	-	285	-	31	-	10.9
12-300	-	107	-	19	-	17.8
12-301	-	112	-	25	-	22.3

The test papers for students in the provincial sample were scored by Manitoba Education. At grades 6, 9, and 12 all items were in a multiple choice format with (in most cases) either four or five choices. Answers were placed on a standard answer sheet for machine scoring. At the grade 3 level answers were written directly in the test booklet. The format of grade 3 items varied considerably and included completion items, written answer computations, and multiple choice items involving circling the correct answer. All scores for the grade 3 sample were transferred by Assessment Section personnel to the standard answer sheets for machine reading.

Step 6: Interpretation and Reporting of Results

The Preliminary Report provides results at each grade level for each subtest and each item. Item data can be examined together with a copy of the test booklet. Subtest mean scores are presented and these provide the best indicators of performance. No overall score for a grade level is given because it yields little useful information, as the main purpose of this curriculum assessment is to look at the individual topics in the mathematics programs.

The Final Report presents a summary of the results at all grade levels and details of the conclusions and recommendations. The interpretation of results and the development of recommendations was carried out by the TAC and the Contract Team augmented by two or three teachers at each grade level.

A Summary Report provides a short summary of the findings and recommendations at each grade level. It is intended to apprise teachers of results important to their classroom work, and to inform the other educational constituencies of the present status of curriculum strengths and weaknesses.

Comparison Testing: 1981 and 1986

In late May of 1986 samples of students in grades 3, 6, 9, and 12 were administered the 1981 assessment tests in order to assess changes in performance over the five year period. Of the groups originally tested, only Mathematics 301 was not retested because of significant changes in that curriculum since 1981.

The Teacher Survey

In addition to the student assessment, teachers at the four grade levels were surveyed to gain information on Demographic and Classroom Organizational Data; Classroom Activities; Use of Calculators and Computers; Teacher Use of Guides, Texts, and Resource Material; Student Evaluation; views on issues in Curriculum and Instruction; and, briefly, areas in which they would like more professional development work.

Questionnaires were sent to a sample of teachers at grades 3, 6, and 9 and to all teachers teaching Mathematics 300 or Mathematics 301.

French Language Tests and Questionnaires

French language versions of the student tests and teacher questionnaires were prepared at all four grade levels. The results contained in this report include data from English language and French immersion schools. Français schools were treated as a separate group and tests were administered in grades 3, 6, and 9. Reports for these schools are published separately.

CHAPTER III

GRADE 3 RESULTS

The Grade 3 assessment instruments are based upon learning objectives in the Provincial Curriculum Guide. Five broad areas were assessed: Number Systems, Operations & Properties; Measurement; Geometry; Graphing; and Problem Solving. The analysis of the results contains a subtest score for each area and subtest. As well, a subtest on Word Problems was drawn from all areas. Two major changes from the 1981 Assessment included a subtest on Estimation and a subtest on nonroutine Problem Solving.

The Grade 3 Assessment contained 100 items and required a total writing time of 60 minutes with a break after 30 minutes. The Assessment sample consisted of 1282 students, randomly selected from across the province, 9.2% of the Grade 3 public school population.

Achievement Results

The actual results are presented in Table III-1. Each of the subtests is discussed in turn. For details of student performance on individual test items, and specifications of the subtests to which items belong, refer to the Preliminary Report.

The questions used as examples below are either multiple choice or short-answer. The correct responses are indicated by asterisks. In the multiple choice items, the percentage of students choosing each response is indicated in front of each response. In the short-answer items, the percentage of students making particular errors is indicated in front of the particular errors.

I. Number Systems, Operations, and Properties

I.1 Concepts of Whole Numbers. The overall performance in the subtest on Concepts of Whole Numbers was 78%. The more difficult items were those dealing with rounding off.

(6) Round off to the nearest ten: 63 _____

50% *A) = 60
5 B) = 70
18 C) = 6
22 E) unidentifiable errors[1]
5 N.R.

[1] This indicates that 22% made a variety of errors or made errors that did not seem to make sense.

(7) Round off to the nearest hundred: 769 _____

42% *A) = 800
7 B) = 700
8 C) = 770
14 D) = 7
23 E) unidentifiable errors
5 N.R.

Although 50% and 42% respectively answered these two items correctly, about one-fifth selected a response which indicated unidentifiable errors. Such a low success rate on these two items indicates that students do not have a sufficient understanding of the concept of rounding off.

Table III-1

Provincial Results - Grade 3

	Subtest	Item Numbers	Number of Items	Percent Correct
I.	NUMBER SYSTEMS, OPERATIONS, AND PROPERTIES			
	1. Concepts of Whole Numbers	1-7	7	78
	2. Place Value	8-11	4	86
	3. Addition & Subtraction	12-36	25	69
	4. Multiplication & Division	51-72	22	72
	5. Fractions	73-76	4	62
	6. Patterns	77-79	3	89
	Total: Number Systems, Operations, and Properties		65	73
II.	MEASUREMENT			
	1. Linear Measurement	80-88	9	68
	2. Area, Volume, and Capacity	89-92	4	54
	3. Money, Time and Temperature	93-98	6	65
	Total: Measurement		19	64
III.	GEOMETRY	37-44	8	78
IV.	GRAPHING	45-46 99-100	4	78
V.	PROBLEM SOLVING	47-50	4	30
VI.	WORD PROBLEMS*	33-36 47-50 71-72 88	11	51
VII.	ESTIMATION*	22-23 31-32	4	23

*Subtests VI and VII contain items that overlap with other subtests.

I.2 Place Value. Place Value was well handled and students appeared to have a good understanding of this concept as indicated by an 86% or better performance rate, on items such as item 9:

(9) What place does the 6 hold in 627?

90%	*A)	☐ = hundreds
4	B)	☐ = tens
4	C)	☐ = ones
1	E)	unidentifiable errors
1	N.R.	

I.3 Addition and Subtraction. The items on Addition and Subtraction were generally well done with the exception of four items on Estimation (See VII, discussion on Estimation) and four items on Subtraction. Items 15, 18, & 21 had somewhat lower scores (73%-79%) as compared to the other Addition items which had a success rate of 84% or better. These three items all involved regrouping and three addends. The response analysis indicates that approximately 12% of the students made a calculation error while approximately 5% made a regrouping error.

79%	*A)	= 107
11	B)	= calculation error
0	C)	= operation error
3	D)	= regrouping
5	E)	unidentifiable errors
2	N.R.	

(15)
57
18
+ 32
☐

Student results were lower in items with zero in the minuend (items 25, 27, 29, 30) with only 60% of the students answering correctly. Reversal errors accounted for 25% of the incorrect responses in these questions, while 4% of the errors were due to calculation/basic fact, and another 3% due to regrouping errors.

60%	*A)	= 63
3	B)	= calculation error
26	C)	= reversal error
3	D)	= regrouping
6	E)	unidentifiable errors
2	N.R.	= non-répondants

(25)
90
- 27
☐

I.4. Multiplication and Division. Performance on this subtest was satisfactory with an overall success rate of 72%. Fourteen of the twenty-two items dealt with basic facts in Multiplication and Division. Items 62 and 66 (69% and 67% respectively) lowered the overall performance level. It should be noted that the Manitoba Curriculum Guide recommends that students master multiplication facts for products up to forty.

(62) 36 ÷ 6 = ☐

69% *A) = 6
8 B) = calculation error
2 C) = operation error
13 E) unidentifiable errors
8 N.R.

Multiplications items involving multiples of 10 and 100 and 2 digit by 1 digit factors caused the most difficulty on this subtest. Correct responses ranged from 38%-72%.

I.5 Fractions. The subtest on Fractions included four items, two involving writing of fractions and two showing the fraction on a diagram.

(74) Write the fraction that shows how much is shaded?

_____

62% *A) = $\frac{2}{3}$
8 B) = $\frac{1}{3}$
9 C) = $\frac{2}{1}$ or 2
3 D) = $\frac{3}{2}$
14 E) unidentifiable errors
4 N.R.

76 Circle $\frac{1}{2}$ the set of trees.

52% *A) = 3 circled in 1 set
2 B) = more than 3 circled
25 C) = less than 3 circled
4 D) = 3 trees circled, but not in a set
11 E) unidentifiable errors
6 N.R.

The overall performance on this subtest was 62%. In item 76, 25% of the students gave an answer less than 3.

I.6 Patterns. The three pattern recognition items had the highest percent correct of any subtest, 89%. This area was rated very satisfactory by the Technical Advisory Committee.

II. Measurement

II.1 Linear Measurement. The subtest on Linear Measurement consisted of nine items. The overall performance rate was 68%. Performance on items 83 and 84 indicate some confusion as to what a metre and centimetre are and the relationship between the two units of measure.

83 7 metres is the same length as

22% A) ☐ 7 cm (centimetres)
18 B) ☐ 70 cm (centimetres)
56 *C) ☐ 700 cm (centimetres)
4 N.R.

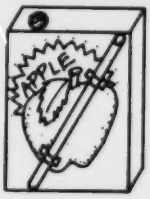
II.2 Area, Volume, and Capacity. The subtest in this area consisted of four items. The Technical Advisory Committee considered the performance level of 54% to be unsatisfactory. Of the two items on Area, item 90 caused the greater difficulty. Correct responses were given by 47% of the students, 13% answered 6; suggesting the students counted the half units as whole units, and 10% answered 4, indicating the students ignored the two half units.

(90) Find the area of this shape. Each box is one square centimetre (cm^2). _____ cm^2

47%	*A)	5 cm^2
13	B)	6 cm^2
3	C)	12 cm^2
10	D)	4 cm^2
15	E)	unidentifiable errors
12	N.R.	

Items 91 and 92, dealing with capacity indicate that students are not adequately familiar with litres and millilitres. For example in item 92, 48% answered correctly. It is possible that some students would be unfamiliar with the "juice box".

(92) How much a small juice box holds would most likely be measured in



48%	*A)	☐ millilitres
44	B)	☐ litres
8	N.R.	

II.3 Money, Time and Temperature. In this subtest there were six items. On item 93, less than half the students answered correctly. The dollar or coin amounts were omitted by 13% of the students while 17% incorrectly recorded the number.

(93) How much money? _____

49% *A) = $2.51 (251¢)
4 B) = $0.51
9 C) = $2.00
17 D) = correct answer, incorrect recording
13 E) = 2 or more errors
8 N.R.

Item 94 was answered correctly by 55% of the students, while 20% answered February. Errors on these items may have been due to reading interpretation.

(94) What month comes after the second month of the year?

20% A) ☐ February
7 B) ☐ April
55 *C) ☐ March
9 D) ☐ January
9 N.R.

Item 95, dealing with days of the week was answered correctly by 74%.

95 If tomorrow is Friday, today would be

74%	*A)	☐ Thursday
16	B)	☐ Saturday
1	C)	☐ Friday
10	N.R.	

Items 96 and 97 on time had performance rates of 74% and 69%. The digital clock item appeared somewhat easier to complete than reading the clock-with-hands item.

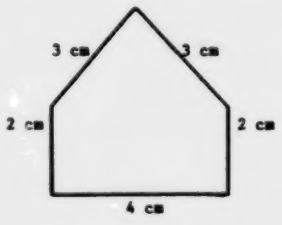
Item 98 on temperature was answered correctly by 71% of the students.

III. Geometry

Performance in the Geometry subtest (78%) was rated satisfactory by the Technical Advisory Committee. Students had difficulty on items 41, identifying parallel lines and 42, finding perimeter. The most common error in the latter item was to select one side only.

42 Find the perimeter of this shape. _____ cm

68%	*A)	14
1	B)	+ 1 side (16,17,18)
0	C)	- 1 side (10,11,12)
18	D)	1 side only (4,3,2)
4	E)	unidentifiable errors
9	N.R.	



IV. Graphing

This subtest consisted of four items. Performance was satisfactory. An item involving two steps to solve the question proved to be a little more difficult than single step items as illustrated by items 99 and 100.

(99) Who collected more stickers than Rick? _____

85% *A) Ann
0 B) Tom
0 C) Rick
0 D) Sarah
4 E) Incorrect
11 N. R.

(100) How many stickers do Sarah and Ann have together? _____

64% *A) 12
4 B) ± 1
3 C) $\overline{9}+3$
0 D)
18 E) Incorrect
11 N. R.

V. Problem Solving

This subtest contained nonroutine problem solving items. The mean performance was 30%. The Technical Advisory Committee felt that the results were satisfactory given that nonroutine problem solving requires a higher level of thinking skills for which children at that age level may not be prepared. Responses may also indicate that at the grade 3 level, many children are still using concrete materials to help them solve problems. Item 49 is an example of a nonroutine problem from the test.

49 You are waiting to buy popcorn at the show.
There are 5 people in front of you.
There are 4 people behind you.
How many are in line?

_____

41% *A) = 10
42 B) = 9
6 E) unidentifiable errors
11 N. R.

VI. Word Problems

The subtest on Word Problems containing items from Part I, Addition and Subtraction, Multiplication and Division, and Part II, Measurement was considered by the Technical Advisory Committee to be satisfactory. Students had more success with the addition and multiplication items than with the subtraction and division items. They had a success rate of 57% on subtraction word problems. An illustrative example is item 36.

36 Terry saw 365 animals at the zoo.
If 137 were sleeping, how many animals were awake?

_____

55% *A) = 228
13 B) = error in calculation, including 232 reversal
7 C) = operation error
2 D) = regrouping
17 E) unidentifiable errors
6 N.R.

The single item on multiplication (item 71) was correctly answered by 67% of the students but 24% selected the wrong operation.

71 There were 5 clowns. Each clown had 3 hats. How many hats were there in all? _____

67% *A) 15
1 B) calculation error (14,16)
24 C) operation error (8,2)
5 E) unidentifiable errors
3 N.R.

The division problem was answered correctly by 50% of the students: 21% made an operation error.

VII. Estimation

This subtest contains items from Part I, Addition and Subtraction and was considered unsatisfactory by the Technical Advisory Committee. In item 22, only 12% chose the response that one would get when the correct procedure of rounding first and then carrying out the indicated operation is employed. Approximately 72% probably added the two numbers first and then rounded the sum, which, of course, is an incorrect procedure for estimating. It is conceivable however, that some students may have rounded off first and then carried out the indicated operation and then realized that because the numbers were both rounded upwards, it would be wise to adjust the sum downwards by 10.

22 Estimate the sum: 16 + 27 =

11% A) ☐ 30
3 B) ☐ 60
12 *C) ☐ 50
72 D) ☐ 40
2 N. R.

In Item 32, 28% chose the response that one would get when the correct procedure of rounding first and then carrying out the indicated operation is employed. It is likely that the majority of those who chose 20 as their answer, incorrectly found the actual difference first and then rounded off their answer.

32 Estimate the difference: 73 - 57 =

49%	A)	☐	20
28	*B)	☐	10
11	C)	☐	40
8	D)	☐	30
4	N. R.		

Estimation requires two steps. Firstly each number is rounded off to the nearest 10 in the two examples above and secondly the indicated operation is carried out. Thus it is incorrect to add, subtract, multiply, or divide first. The Mathematics Curriculum Guide is quite specific on this point.

Recommendations

Overall performance on the assessment is considered to be satisfactory by the Technical Advisory Committee. The two subtests on Problem Solving and Estimation were the weakest areas. The Committee makes the following recommendations for Grade 3.

TO TEACHERS

That problem solving continue to receive emphasis.

That teachers give more emphasis to the study of area, volume, and capacity, a topic which is also important in the science curriculum.

That teachers pay particular attention to the transition from concrete manipulation to symbolic recording of students' work.

That teachers be reminded that, as stated in the Curriculum Guide, estimation is a two-step process. Estimation is particularly important with the use of calculators.

TO SCHOOL DIVISIONS

That problem solving become an integral part of the curriculum at all levels.

That teachers be provided with appropriate materials and professional development to teach measurement (length, area, volume, and capacity).

TO MANITOBA EDUCATION

That Manitoba Education support the premise that problem solving is an integral part of the curriculum and of mathematics classroom activity at all levels.

That professional development be provided in measurement concepts.

TO FACULTIES OF EDUCATION

That problem solving techniques receive greater emphasis in the teacher education programs.

CHAPTER IV

GRADE 6 RESULTS

The Grade 6 assessment instruments are based upon learning objectives in the Provincial Curriculum Guide which were priorized by teachers. Five broad areas were assessed: Number Systems, Operations, and Properties; Measurement; Geometry; Graphing; and Problem Solving. The analysis of results contains a subtest score for each area and subtest, as well as a subtest on Word Problems drawn from all areas, and in the only major change from the 1981 assessment, a subtest on nonroutine problem solving.

The test contained 90 items and required a total writing time of 90 minutes with a break in the middle. The Assessment sample consisted of 1391 students randomly selected from across the Province, just under 10% of the grade 6 population.

Achievement Results

The actual results are presented in Table IV-1. Each of the subtests is discussed in turn. For details of student performance on individual test items, and specification of the subtests to which items belong, refer to the Preliminary Report.

I. Number Systems, Operations, and Properties

I.1 Place Value, Regrouping, and Rounding Off. In the subtest on Place Value and Rounding Off, the overall performance was at 67%. The more difficult items were those dealing with decimals. Confusion was particularly manifested between the tenths and hundredths place in such items as:

(7) 54.187 rounded off to the nearest hundredth is

11%	A)	54.00
8	B)	54.18
57	*C)	54.19
24	D)	54.20
0	N.R.	

While 57% of the students answered this item correctly, almost one-fourth selected response (D), which suggests that students are thinking either of tenths or of a whole number rounded to the nearest ten, i.e., 18 or 19 rounded to 20.

Table IV-1

Provincial Results - Grade 6

Subtest	Item Numbers	Number of Items	Percent Correct
I. NUMBER SYSTEMS AND OPERATIONS			
I.1 Place Value, Regrouping, and Rounding Off	1-8	8	67
I.2 Equalities and Inequalities	9-12	4	72
I.3 Factors, Primes and Composite Numbers	13-16	4	56
I.4 Properties	17-20	4	72
I.5 Addition and Subtraction	21-27	7	69
I.6 Multiplication of Whole Numbers	28-32	5	71
I.7 Division of Whole Numbers	51-56	6	60
I.8 Fractions and Percent	57-63	7	65
I.9 Operations with Fractions	64-71	8	51
I.10 Operations with Decimals	72-78	7	50
Total		60	63
II. MEASUREMENT	33-41	9	54
III. GEOMETRY	42-49	8	60
IV. GRAPHING	79-84	6	76
V. PROBLEM SOLVING (nonroutine)	85-87 89-90	5	27
VI. WORD PROBLEMS (routine)	24,56,67 70,75 85-87 89,90	10	43

I.2 Equalities and Inequalities. Inequalities were well handled for whole numbers; students clearly understand the inequality symbols, as evidenced by the 90% correct response on an item testing this objective. On the other hand, a more difficult item requiring comprehension and application, was correctly answered by only 55%, with 33% choosing answer (B), which suggests an equality:

(12) $3 + \square < 12$

Which number(s) can go in the $\square$ to make this number sentence **TRUE**?

55%	*A)	Any number less than 9
33	B)	9
11	C)	Any number greater than 9
1	N.R.	

Comparing two decimals also caused some problems as indicated by this item which was answered correctly by 53% of the students:

(10) 0.067 is greater than

12%	A)	0.07
15	B)	0.076
53	*C)	0.06
19	D)	0.10
1	N.R.	

Other responses are spread rather evenly over the other answers indicating no particular error patterns.

I.3 Factors, Primes, and Composite Numbers. In this subtest students were able to select the greatest common factor of 54 and 60, but only 50% were able to correctly select the set of common factors of 18 and 24. The prime factors of 42 (item 13) were correctly chosen by only 24% of students, while 46% included 6 as a prime factor. The overall performance on this subtest was 56%.

I.4 Properties. The subtest on Properties contained items dealing with the commutative property of addition, the associative properties of addition and multiplication, and the property of 1 in multiplication. The latter caused no difficulty (94% correct), while the others ranged from 58% on associativity of multiplication to 69% on commutativity of addition. The item format may be the cause of some trouble although the series of items appeared in order of difficulty. Item 18 (66% correct) is illustrative:

(18) If (16 + 3) + 5 = n + (3 + 5), then n must be

5%	A)	5
7	B)	3
66	*C)	16
20	D)	19
1	E)	
1	N.R.	

I.5 Addition and Subtraction of Whole Numbers. The items on addition and subtraction were generally very well done, with the exception of an item on estimation:

(27) By rounding off to the nearest 10, an estimate of 364 - 48 would be

8%	A)	300
28	*B)	310
22	C)	316
41	D)	320
1	N.R.	

Estimation requires two steps: 1) round each number, in this case, to the nearest 10, and 2) then carry out the indicated operation on the rounded numbers. It is thus incorrect to subtract first and then round off, as 41% of students may have done (D). A further 22% selected response (C), which indicates subtraction without any estimation or rounding. For estimation difficulties in grade 3, see page 26.

I.6 Multiplication of Whole Numbers. Performance on multiplication was considered by the Technical Advisory Committee to be quite good, with 71% correct. The only item below 75% was the one on estimation, with similar errors to those on the subtraction item (27) shown above. Over 60% either did not round at all or likely rounded after multiplying.

I.7 Division of Whole Numbers. In this subtest performance was quite good except on two items which pulled down the average score which nevertheless was 60%. The item which should be of concern to all teachers is the following:

(52) $7 \div 0 =$

56%	A) 0
15	B) 7
1	C) 1
26	*D) impossible
1	N.R.

Such results can only be attributed to poor comprehension. It is an unacceptable result which teachers should examine carefully. An item on the relationship between divisor, dividend, quotient, and remainder was also poorly answered.

I.8 Fractions and Percent. The overall performance on this subtest was 65% correct, a percentage that accurately represents the performance on individual items. Only the following item fell well below the average:

(63) In a class of 20 students, there are 9 girls and 11 boys. The ratio of boys to girls is

35	A) 9:11
7	B) 9:20
7	C) 11:20
49	*D) 11:9
1	N.R.

Either students did not understand the meaning of ratio in this context or they were not reading carefully.

I.9 Operations with Fractions. A single item on the addition of two fractions with like denominators received a response rate of 71%. All other items fell between 41% and 54% correct, a consistent but mediocre performance. Conceptual understanding should enable

students to handle an item such as the following even if they have not mastered the computational algorithm.

(69) $8 - \frac{1}{3} =$

44%	*A)	$7\frac{2}{3}$
13	B)	$8\frac{2}{3}$
19	C)	$7\frac{1}{3}$
22	D)	$\frac{7}{3}$
1	E)	
1	N.R.	

I.10 Operations with Decimals. The overall performance on operations with decimals is similar to that of operations on fractions, but the item difficulties ranged from 23% to 86% correct. Straight forward computation was satisfactorily done except when students were asked to multiply 5600 x 0.01. Only 23% got this item correct, and more than half indicated 5600 as the answer. Again, conceptual weaknesses, as indicated in Section I.7 (Division), were noted. An item requiring students to multiply two decimals (item 77) was done correctly by 48%. Only one-quarter of the students were able to identify the location of 1.03 on the number line with division marks of tenths.

II. Measurement

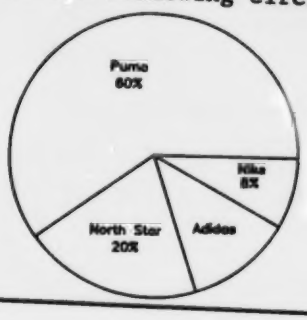
Students did satisfactorily on items dealing with what metric unit was appropriate in a given situation. That kilometre is the same as 1000 metres was recognized by 64% and 70% correctly estimated the length of a pen in centimetres. However, only 29% were able to identify 0.5 kg as the same as 500 g. Items requiring students to calculate the perimeter of a rectangle (given the length and width) and the area of a square (given its perimeter) were correctly answered by 35% and 24% percent respectively. These latter results indicate some difficulties on the topic of area and perimeter.

III. Geometry

Overall performance in the area of Geometry was considered by the Technical Advisory Committee to be very satisfactory with a 60% correct. Less than 40% of students were able to select the isosceles triangle out of a set of five triangles. Approximately 60% could name the diameter and radius in a circle diagram, and the same number identified the "flip image" of a simple figure. Slightly over half could identify an obtuse angle and find an angle named in the standard manner ($\angle$ XWZ).

IV. Graphing

The six graphing items had the highest overall performance of any subtest: 76%. Students did well in reading a bar graph and in determining which of five bar graphs correctly represented given data. Three items were built around the following circle graph:



81 What percent of the boys wear Pumas?

1%	A)	12%
2	B)	20%
93	*C)	60%
2	D)	8%
2	N.R.	

Over 90% could tell what percent of boys wear Pumas and which brand of runners was worn by the fewest boys. However, only 50% were able to determine what percent of boys wear Adidas.

V. Problem Solving

This subtest contained nonroutine problem solving items. The overall 27% correct suggests that more work in this area is needed. The best item (53%) was one in which students were asked to identify the arithmetic operations required to solve a word problem. No solution was required.

Other items required finding patterns, looking for unneeded information in a word problem and dealing with a problem in which they needed to recognize that two answers were possible. In the following problem the response was perhaps predictable:

89 If 8 dishes of tiger food are set out 10 m apart, what is the shortest distance a hungry tiger would have to travel to eat all the food starting at the first dish?

7%	A)	100 m
4	B)	90 m
61	C)	80 m
12	*D)	70 m
14	E)	18 m
2	N.R.	

If students had drawn a diagram, it is likely that a far greater proportion would have answered correctly. In fact, only 12% selected the correct response (D), and 61% chose (C).

True problems are, by definition, difficult and one should have reasonable expectations of student performance. However, responses well below the chance level indicate some difficulties.

VI. Word Problems

This subtest contains all the routine and nonroutine problems that occurred in the various subtests in this study. The overall average for the ten problems was 43%. The nonroutine problems were discussed in some detail in section V above. The five routine problems are standard word problems , requiring application of the basic arithmetic operations with whole numbers, fractions, and decimals. These five routine problems together have an average of 60%. The following problem is the only one in which less than half of the students were correct:

(67) Johnny had a bag of 36 candies. He ate $\frac{1}{3}$ of them himself and Betsy ate $\frac{1}{4}$ of them. In all, how many candies were eaten?

44%	*A)	21 candies
23	B)	24 candies
20	C)	28 candies
11	D)	30 candies
1	N.R.	

Recommendations

Overall performance is considered to be satisfactory by the Technical Advisory Committee. The two subtests on operations with fractions and decimals were the weakest areas. Misconceptions such as 7/0 = 0 are not acceptable, but otherwise computation with whole numbers was adequately done, including application in word problems. Results on nonroutine problem solving suggest that more effort is required here. The concept of estimation appears to be poorly understood. Students likely rounded their answer rather than rounding the initial numbers in the computation in order to make that computation easier.

The following recommendations are made by the Technical Advisory Committee:

TO TEACHERS

That problem solving continue to receive emphasis at all levels.

That concrete materials be used in the introduction and maintenance of concepts and skill development.

To Teachers (Cont'd.)

That teachers pay particular attention to the transition from concrete manipulation to the symbolic representation of students' work, e.g., in the study of perimeter and area.

That more attention be given to rounding with decimals and more generally to decimal place values less than 1.

That work with decimals, both computationally and conceptually, be given increased emphasis.

That work with fractions, both conceptually and computationally, be given increased emphasis.

That continued attention be paid to the teaching of the SI metric system.

That greater emphasis be given to understanding concepts in division.

That closer attention be paid to estimation in numerical computation, rounding off, and the relationship between them.

TO SCHOOL DIVISIONS

That problem solving become an integral part of the school curriculum and of mathematics classroom activity.

That consideration be given to professional development workshops in problem solving, the metric system, and the teaching of concepts in elementary mathematics.

TO MANITOBA EDUCATION

That Manitoba Education support the premise that problem solving is an integral part of the curriculum and of mathematics classroom activity at all levels.

That Manitoba Education assist with and promote professional development workshops in problem solving, the metric system, and the teaching of concepts in elementary mathematics.

TO FACULTIES OF EDUCATION

That greater attention be focussed on the teaching of concepts in elementary mathematics.

That problem solving techniques receive greater emphasis in teacher education programs.

CHAPTER V

GRADE 9 RESULTS

The grade 9 assessment instruments are based upon learning objectives in the provincial curriculum guide. The test consisted of 77 items in three parts: Part A in which calculators were not allowed, and Parts B and C in which calculators were allowed. Parts A and B were scored in six subtests: Real Number System, Construction Geometry, Open Expressions, Equations, Word Problems (routine), Word Problems (nonroutine). Part C was divided into 5 options: Algebra, Consumer Related Topics, Coordinate Graphing, Statistics, and Geometry. All of the skills tested are found in the Grade 9 provincial curriculum guide.

A total of 31 schools comprised the provincial sample; this is just over 10% of the schools with grade 9 students. There were 2138 students in this sample.

Achievement Results

The actual results for the core topics are shown in Table V-1. Results for the options are reported in Table V-2. Provincial results are reported for the algebra option since 95% of the students selected it as one of their options. Other options were selected by a much smaller number of students; therefore data are reported on a stratum basis. Following the tables, each of the subtests is discussed. For details of student performance on individual test items, and specification of the subtests to which items belong, refer to the Preliminary Report.

Table V-1

Provincial Results - Grade 9 Core Topics

Subtest	Item Numbers	Number of Items	Percent Correct
I. Real Number System	1-3,5,6,8-11 15,16,54,61	13	50
II. Construction Geometry	24,25,51 71,72	5	51
III. Open Expressions	13,14,17-19 56-60	10	62
IV. Equations	20-23,62-65	8	61
V. Word Problems (routine)	4,7,12,52 53,55,66-70	11	53
VI. Word Problems (nonroutine)	73-77	5	45

CORE TOPICS

I. Real Number System

This subtest dealt with the basic operations in signed decimals and fractions, conversions of fractions and decimals, squares and square roots, exponents, and the law of Pythagoras. A performance of 50%, indicates that there are areas of weakness. Conversion of decimals to fractions is one area of concern. In item 5, 30% of the students chose D as the correct answer. This indicates that students may have merely picked the pattern of nines in the response as they recalled studying that rule in their course.

(5) 0.52 is equivalent to

49%	*A)	$\frac{13}{25}$
11	B)	$\frac{21}{50}$
5	C)	$\frac{1}{2}$
30	D)	$\frac{52}{99}$
4	E)	$\frac{13}{50}$

Although 50% of the students answered item 1 correctly, 27% of the students chose A, indicating that some students have a poor understanding of place value.

(1) (-0.4)(0.5) is

27%	A)	-2.0
50	*B)	-0.2
10	C)	-0.02
9	D)	0.2
4	E)	2.0

Students did reasonably well with the signs in the signed fractions and decimals except in item 3. Here 30% of the students chose A as the correct answer. This indicates that the students merely added the two fractions, ignoring that the signs of the fractions were opposites. Teachers are reminded that students should solve this problem by rewriting the fraction with two components,

e.g., $-2\frac{1}{3} = -2 - \frac{1}{3}$.

(3) $-2\frac{1}{3} + 3\frac{4}{9}$ is

30%	A)	$-5\frac{7}{9}$
8	B)	$-1\frac{1}{3}$
42	*C)	$1\frac{1}{9}$
11	D)	$1\frac{1}{3}$
9	E)	$5\frac{5}{9}$

Students scored very well (75%) in finding the square root of the perfect square, 900, but when asked to find the value of the square root of a non-perfect square in item 10, many missed the concept. One of the first three answers was picked by almost 40% of the students. This would indicate that the concept square root is not well understood. Without the use of a calculator, this type of question develops estimation skills. It was noted earlier in both the grade 3 and grade 6 parts of the assessment that estimation skills were weak.

(10) The value of $\sqrt{51}$ is between

19%	A)	5.5 and 6.0
7	B)	6.0 and 6.5
12	C)	6.5 and 7.0
51	*D)	7.0 and 7.5
10	E)	7.5 and 8.0

In comparing items 11 and 16, it would seem that many students see these two items as being the same item. Teachers should carefully point out the differences, i.e. -2^4 is read as the opposite of 2^4.

(11) $(-2)^4$ is equivalent to

6%	A)	-32
21	B)	-16
11	C)	-8
6	D)	8
56	*E)	16

(16) -2^4 is equivalent to

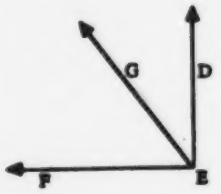
8%	A)	-32
35	*B)	-16
11	C)	-8
5	D)	8
41	E)	16

II. Construction Geometry

Overall performance was 51%. The range from 33% on a basic definition of corresponding angles to 64% on complementary angles, shows many inconsistencies. It is possible that some students may have done item 25 (complementary angle), item 51 (supplementary angle) and item 72 with a protractor rather than performing calculations. The use of a protractor was not explicitly prohibited in the directions.

(25) $\angle DEF$ is a right angle. The measure of $\angle DEG = 43°$. The measure of $\angle GEF$ is

3%	A)	147°
10	B)	137°
12	C)	57°
9	D)	53°
64	*E)	47°
2	No Response	

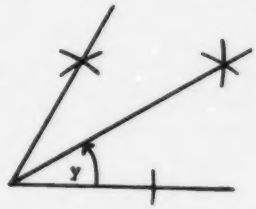


(51) Points A, B, and C are on the same straight line. If the measure of ∠ ABD is double the measure of ∠ DBC, then the measure of ∠ABD is

2%	A)	30°
24	B)	60°
7	C)	90°
60	*D)	120°
6	E)	180°

(72) The number of degrees of angle y in the construction is

8%	A)	15
64	*B)	30
20	C)	45
5	D)	60
3	E)	90

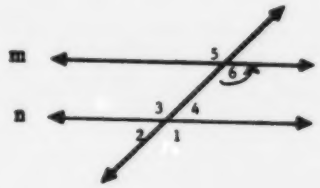


Note: **All arcs are drawn with equal radii.**

Performance on item 24 indicates poor knowledge of the definition as only 33% of the students selected the corresponding angle.

(24) If line m and line n are parallel, the corresponding angle to ∠ 6 is

21%	A)	∠ 5
17	B)	∠ 4
20	C)	∠ 3
8	D)	∠ 2
33	*E)	∠ 1
1	No Response	



III. Open Expressions

The overall performance on this subtest is satisfactory at 62%. Item 57, which has a score of 72%, is an example of an item that is very well done.

(57) If x = 1, y = 2, then the value of -2x - 3y - 5 is

7%	A)	-15
72	*B)	-13
10	C)	-1
6	D)	3
5	E)	13

Students had difficulty with only 2 items, 18 and 59. In item 18, 39% of the students made a predictable but incorrect choice in choosing C. Furthermore, 23% of the students made an incorrect choice with A. Students need to realize that squaring a number is not the same as finding twice the number.

(18) "Twice the sum of some number and four" may be expressed as

23%	A)	$n^2 + 4$
6	B)	2n = 4
39	C)	2n + 4
30	*D)	2(n + 4)
2	E)	2(n)(4)

The performance of 40% on item 59 is not acceptable for grade 9. Many students had difficulty with the signs.

(59) (-2x + 3) - (x - 6) is equivalent to

23%	A)	-3x - 3
11	B)	-x + 9
40	*C)	-3x + 9
17	D)	-x - 3
9	E)	-3x - 9

IV. Equations

The overall performance of 61% on equations was considered satisfactory by the Technical Advisory Committee. Students scored very well on the simpler equations, items 20 - 23, and scored poorly on the more complicated items 62 - 65. Scores range from 88% on item 21 to 42% on item 63.

(21) Solve for y: $5y = -20$

2%	A)	-100
4	B)	-15
88	*C)	-4
5	D)	4
1	E)	15

(63) Solve for x: $-2(x + 5) = 18$

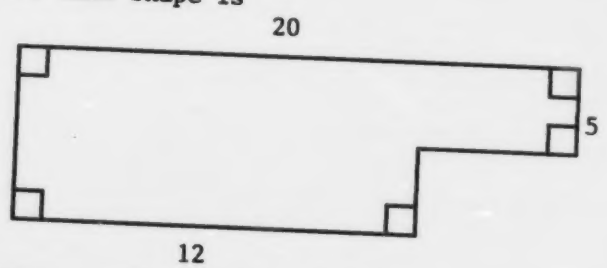
42%	*A)	-14
12	B)	-11.5
21	C)	-4
15	D)	4
10	E)	14

V. Word Problems (routine)

The overall performance on word problems with decimals, fractions, integers and percents is satisfactory. Performance levels range from poor to acceptable. Students had difficulty with the applications of Pythagorean triples and perimeter. For example in item 12 only 27% of the students chose the correct answer E. Students seem to have the misconception that one adds up the numbers shown around a figure rather than finding the total distance around a figure. There seems to be a tendency to operate blindly on numbers rather than to make a decision regarding how the problem should be solved.

(12) The perimeter of this shape is

2%	A)	43
58	B)	48
9	C)	54
4	D)	56
27	*E)	62



Only 26% of the students answered item 55 correctly. Forty-four percent who chose A as their answer apparently did not apply the law of Pythagoras. The question immediately before this one also required the application of the law of Pythagoras. Students were presented with a right-angled triangle whose leg dimensions were given. They were asked to determine the hypotenuse; 54% were successful. In question 55, the law of Pythagoras was also involved; it seems that the written problem format and the fact that students were to determine the length of a leg caused the great majority of students to be unsuccessful.

55 A 10 m ladder leans against the inside wall of a gymnasium with the bottom of the ladder 6 m from the wall. The distance that the ladder reaches up the wall is

44%	A)	4 m
26	*B)	8 m
17	C)	16 m
4	D)	64 m
9	E)	$\sqrt{136}$ m

Item 52 is an example of a problem which is well done.

52 On Wednesday, the Canadian dollar was valued at \$0.715 in American funds. On Thursday the Canadian dollar rose \$0.008 and on Friday it fell \$0.014. The value of the Canadian dollar at closing on Friday was

6%	A)	\$0.693
77	*B)	\$0.709
5	C)	\$0.719
4	D)	\$0.721
7	E)	\$0.737

Performance on problems involving algebra ranges from 35% to 78%. We cannot assume from this result that the students know how to set up equations. They may have used an alternative method, such as guess and

check, to solve some of the problems. Only 35% answered the translation problem, item 67, correctly.

67 There are 2 more girls than boys in a class of 28 students. If n is the number of boys, an equation that represents the number of students in the class is

32%	A)	2 + n = 28
20	B)	2n + n = 28
35	*C)	n + 2 + n = 28
7	D)	2n = 28
6	E)	2 + n = 28 + n

Item 68 is an example of an algebraic problem that is well done.

68 Twice a number, increased by three, is 48. The number is

6%	A)	15
8	B)	21
78	*C)	22.5
5	D)	25.5
3	E)	43

VI. Word Problems (nonroutine)

Although the performance on nonroutine problems is the lowest mean on the test at 45%, 2 of the 5 items were satisfactory. For example, 61% of the students answered item 75 correctly. Since this problem contains a great deal of reading, this is commendable.

75 Five students ran in a race. John finished 1 metre ahead of Fred. Fred was not in last place. Sue finished 7 metres ahead of Ed. Ed finished 3 metres behind John. John finished 5 metres behind Kathy. The winner of the race was

2%	A)	Ed
5	B)	Fred
7	C)	John
61	*D)	Kathy
25	E)	Sue

Item 77 was answered correctly by 31% of the students. This shows a definite weakness expecially since the multiple choice format would allow, on average, a 20% success rate just by random guessing.

77 The total number of ways to make fifty cents using only nickels, dimes, and any combination of nickels and dimes is

5%	A)	2
19	B)	4
19	C)	5
31	*D)	6
24	E)	8
2%	N.R.	

OPTION TOPICS

The data in table V-2 are reported on a stratum basis with the numbers of students in each stratum reported.

Table V-2

Provincial Results - Grade 9 Option Topics

Options	Stratum**	Number of Students	Average Percent Correct
1. Algebra	all	2021	46
2. Consumer Related topics	1	485	50
	2	*	
	3	191	74
	4	12	62
	5	105	63
3. Coordinate Graphing	1	235	47
	2	*	
	3	148	37
	4	36	38
	5	270	47
4. Statistics	1	17	29
	2	*	
	3	*	
	4	*	
	5	25	72
5. Geometry	1	519	47
	2	*	
	3	*	
	4	18	31
	5	158	53

*Indicates an insufficient number of students for interpretation.

**Strata definitions:
1 Urban
2 Hutterite
3 Other city/Large town
4 Remote/Northern
5 Rural/Small town

Few interpretations can be made from these data. Not all sample schools within a stratum chose the same options. In addition only 5 items were tested in each option. The numbers choosing each option do indicate that very few schools are doing the statistics option.

Conclusions and Recommendations

The Technical Advisory Committee found that, generally, the overall performance of grade 9 students was satisfactory. On the basis of the results of the testing a number of observations and recommendations were made.

Teachers selected two out of five option sections for their students to write, in this assessment. Actually, 95% of the students wrote the Algebra option. This section is designated as Core in the French mathematics program.

Achievement in problem solving is at a low, but not unexpected, level at this point in time. Strengths were evident in routine problem solving while weaknesses were evident in nonroutine problems. There is room for growth.

Students appear to be memorizing rules to convert decimals to fractions rather than using algebra.

Estimation is designated as one of the unifying themes in the Curriculum Guide. The test data indicated weaknesses in estimation concepts. The Curriculum Guide itself suggests few teaching strategies.

The following recommendations are made by the Technical Advisory Committee:

RECOMMENDATIONS TO TEACHERS

That problem solving strategies continue to be integrated into all parts of the mathematics curriculum.

That repeating decimals be studied after the necessary algebraic concepts have been taught.

That estimation concepts be given greater emphasis.

RECOMMENDATION TO SCHOOL DIVISIONS

That professional development be instituted in:

- **problem solving strategies**
- **introductory algebra, with an emphasis on using manipulative materials**
- **estimation concepts**
- **appropriate use of calculators.**

RECOMMENDATIONS TO MANITOBA EDUCATION

That consideration be given to including the Algebra option as a Core topic for all students.

That greater emphasis be given in the Curriculum to:

- **problem solving strategies**
- **estimation concepts**
- **the use of calculators.**

That consideration be given to providing professional development on:

- **teaching introductory algebra with emphasis on using manipulative materials to teachers with limited background in mathematics**
- **estimation concepts**
- **the appropriate use of calculators.**

RECOMMENDATIONS TO FACULTIES OF EDUCATION

That faculties of education ensure that their mathematics education students be familiar with:

- **the teaching of problem solving**
- **the use of manipulative materials in the teaching of algebra**
- **the appropriate use of calculators**
- **estimation concepts.**

CHAPTER VI

GRADE 12 RESULTS

There are two tests at the grade 12 level: one each for Mathematics 300 and Mathematics 301. Each test is based on the objectives specified in the Provincial Curriculum Guide for Grade 12 and selected by teachers as important for assessment in the respective courses.

The discussion of the results will be taken up by course. In each section a summary and discussion of the results will be provided by topic area.

Results: Mathematics 300

The Mathematics 300 test consisted of twelve subtests: five compulsory core topics and seven optional topics. Students were expected to answer all 31 questions in the core topic section and two option topic subtests of 4 items each.

The data for the 300 test are based on a sample of 710 students comprised of entire mathematics 300 classes in each randomly selected, geographically stratified school. There were 107 schools in the population and 19 in the sample. The actual results for the core topics are shown in Table VI-1. Each of the subtests will be discussed in turn. For detailed data the reader is referred to pages 25-28 of the Preliminary Report.

The sample for the option subtests is not representative because of the low numbers of students selecting any given option in certain strata. Therefore, it has not been possible to generalize the option results to the province as a whole. The option topic results are shown by stratum in Table VI-2.

Table VI-1

Mathematics 300: Results on Core Subtests

Core Subtest		Item Numbers	No. of items	Percent Correct
C.I	Polynomial & Rational Functions	1-8	8	56
C.II	Circular Functions	9-19	11	43
C.III	Analytic Geometry	20-23	4	44
C.IV	Exponents and Logarithms	24-27	4	40
C.V	Sequences and Series	28-31	4	42

C.I Polynomials and Rational Functions

The Polynomial and Rational Function subtest was the only one in which students performed reasonably well. It is the only subtest on which the Technical Advisory Committee felt it could give a satisfactory rating.

Throughout the subtest the students' incomplete understanding of the radical function $f(x) = \sqrt{x}$, is obvious as illustrated in the following test items:

(3) The zero(s) of the function $f(x) = \sqrt{x-9} - 4$ is(are)

3%	A)	5
4	B)	7
57	*C)	25
11	D)	-7,25
24	E)	empty set

(7) If $f(x) = 3-x^2$ and $g(x) = \sqrt{6-x}$ then the value of $g(f(1))$ is

57%	*A)	2
2	B)	-2
33	C)	± 2
6	D)	$\sqrt{5}$
1	E)	5

The students who selected (C) in item 7 may have assumed the range of the function $f(x) = \sqrt{x}$ to be all real numbers. We, as teachers, must stress that the range of this function is defined to be the nonnegative real numbers in order that f(x) be a function.

In all other areas of this subtest: identification of functions, properties of functions, graphs of functions, and functional notation, student performance was considered satisfactory.

C.II Circular Functions

Other than on the very basic objectives such as knowing the definition of the tangent function, identifying the sine curve, and solving a right triangle problem, the performance on this subtest was considered unsatisfactory. One of the hypothesized explanations of the marginal performance in this area in 1981 was the unavailability of hand calculators during the examination. In 1987 the calculator was permitted and results still declined.

The students' deficiency in the basic mathematical operations is apparent in the following two items:

(11) If $\sin \theta = 0.3$, then the exact value of $\cos \theta$ is

10%	A)	± 0.3
30	B)	$\sqrt{0.91}$
44	*C)	$\pm\sqrt{0.91}$
8	D)	$\sqrt{0.1}$
7	E)	$\pm\sqrt{0.1}$
1	N.R.	

The students must solve the equation $\cos^2 \theta = 0.91$ and although a better wording of the question might have been "if $\sin \theta = 0.3$, then the exact value(s) of $\cos \theta$ is(are)," it is doubtful whether a significant number of students who chose (B) would have correctly selected (C).

It seems that students are uncertain of the difference between $x^2 = 0.91$ and $x = \sqrt{0.91}$.

(16) An expression equivalent to $\frac{\cos x - 1}{\cos x \sin x} + \frac{\sin x}{\cos x}$ is

24%	A)	$\frac{-1}{\cos x}$
12	B)	$\frac{-1}{\sin x}$
13	C)	$\frac{1+\cos x}{\sin x}$
32	*D)	$\frac{1-\cos x}{\sin x}$
17	E)	$\frac{\cos x - \cos^2 x}{\sin x}$
2	N.R.	

The 24% percent of the students who selected (A) probably deleted "factors" common to either numerator and either denominator. High school teachers have alluded to the students' weakness in operating with fractions. The grade 6 comparison test also indicates a weakness in operations with fractions; the grade 6 performance in this area declined significantly in 1986 from that of 1981 (see Table VII-2 in the next chapter). Unless secondary teachers make a concerted effort to reteach or at least review operations with fractions it is highly unlikely students will be able to prove trigonometric identities and consequently will be unable to solve any but the simplest trigonometric equations.

The preponderance of shorthand notation in mathematics is overwhelming to most non-mathematicians. However, a graduating mathematics 300 student should be familiar with the standard notation used to denote even and odd integers. The poor performance on the following item indicates a lack of experience with the notation or with the tangent function:

15 The domain of $y = \tan x$ is

48% A) $\{x \mid x \text{ is a real number}\}$

11 B) $\{x \mid x \neq k\pi, k \text{ is an integer}\}$

5 C) $\{x \mid x \neq \frac{k\pi}{4}, k \text{ is an integer}\}$

23 D) $\{x \mid x \neq \frac{k\pi}{2}, k \text{ is an integer}\}$

13 *E) $\{x \mid x \neq (2k+1)\frac{\pi}{2}, k \text{ is an integer}\}$

This raises the question of whether the tangent function is taught, or is taught poorly, since a question testing the same concept was answered correctly by only 36% of the students tested in 1981. Furthermore, the choices in 1981 used phrases such as "odd integral multiples," instead of the symbolism, and contained a labeled graph of the tangent function. Removing the graph and using set notation reduced the correct responses significantly.

Many questions indicated that students have partial, but not full, knowledge of concepts. For example:

10 The exact value of $\sin \frac{16\pi}{3}$ is

27% A) $\frac{\sqrt{3}}{2}$

9 B) $\frac{1}{2}$

47 *C) $-\frac{\sqrt{3}}{2}$

10 D) $\frac{-1}{2}$

6 E) $\frac{\sqrt{2}}{2}$

In question 10, response (C) was correctly identified by 47% of students, while 27% knew the correct numeral, but gave the answer with the incorrect sign.

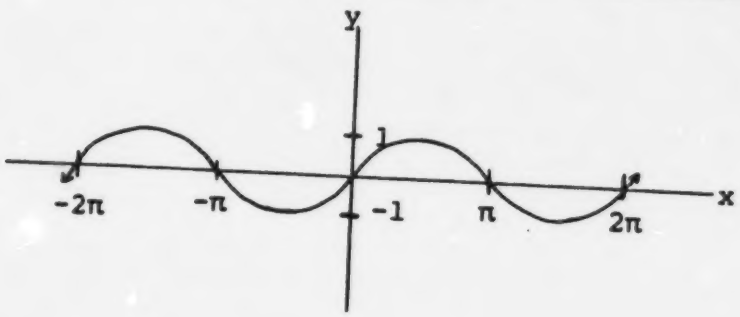
In question 9, the students knew that the tangent is the ratio of the sine and cosine functions, but 20% of them incorrectly selected the reciprocal.

9 Let θ be the arc length on the unit circle from the point (1,0) to the point $P(\theta) = (\frac{-3}{5}, \frac{4}{5})$. The value of tan θ is

4%	A)	$\frac{-3}{5}$
8	B)	$\frac{4}{5}$
20	C)	$\frac{-3}{4}$
62	*D)	$\frac{-4}{3}$
6	E)	$\frac{-5}{3}$

In question 13, students were requested to identify the sine curve. The majority of students knew that the curve was either a sine or cosine curve. Actually 76% chose the correct response.

13



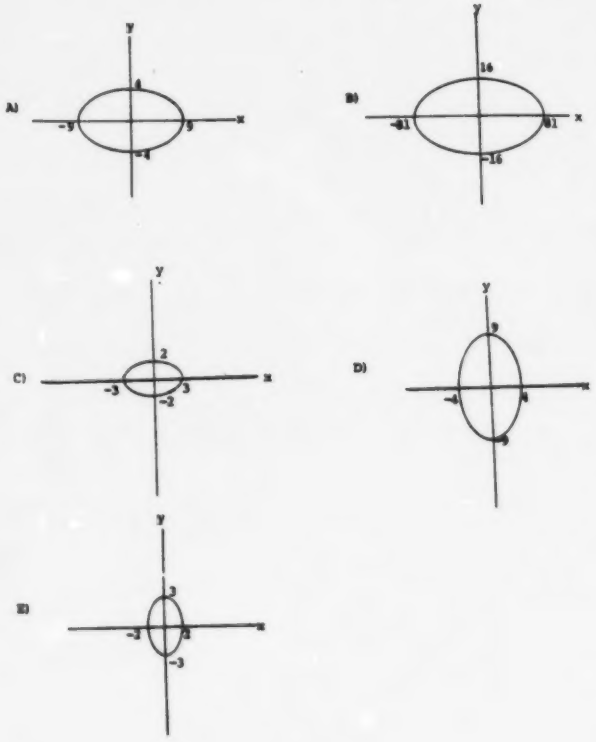
An equation of the above curve is

76%	*A)	y = sin x
14	B)	y = cos x
7	C)	y = tan x
1	D)	y = -cos x
2	E)	y = sec x

C.III Analytical Geometry

Although this subtest produced the second best results of all the compulsory topics, the relative high standing is deceiving. Question 22 was answered correctly by 70% of the participants:

22 A sketch of the graph of $\frac{x^2}{9} + \frac{y^2}{4} = 1$ is



11% A)
8 B)
70 *C)
5 D)
6 E)

This question should be answered correctly by any student who knows how to find the intercepts of a relation. No other question in this subtest of 4 items was answered correctly by more than 35% of the students. These poor results should receive the serious attention of mathematics teachers, school administrators, and the Department of Education.

C.IV Exponents and Logarithms

Three major concepts of exponential and logarithmic functions were tested; the questions relate to their graphs, the solution of their equations, and their applications. The graphing and application of exponential functions was responded to correctly by approximately 50% of the students. The technique of simplifying a logarithmic equation was performed correctly by only 30% of the students.

Question 26 which involved solving a logarithmic equation was correctly answered by 24% of the students. Answer (E), selected by 41% of the students, was a more popular choice than the correct result. They either guessed or recalled some restriction of negatives when dealing with logarithmic functions. They confused the restriction of the domain with a statement about the range of the function.

26 If $\log_3 x - \log_3(x + 6) = -1$, then a solution for x is

24%	*A)	3
12	B)	$\frac{9}{2}$
17	C)	-3
5	D)	-9
41	E)	impossible, since a logarithmic expression cannot have a negative value

The overall performance of 40% correct on this topic was considered unsatisfactory by the Technical Advisory Committee.

C.V Sequences and Series

The results on this topic also received an unsatisfactory rating from the Technical Advisory Committee. Sequences and Series requires some recall of formulae on the part of the students. All that we can conclude is that the topic is being taught, with the possible exception of the sum of an infinite geometric progression which produced 29% correct responses in 1981 and 27% correct responses in 1987.

Item 30 is an example from this subtest. Just under half of the students answered this item correctly.

30 The sum of the first fifty terms of the series

88 + 82 + 76 . . . is

9%	A)	-11 750
49	*B)	- 2 950
11	C)	3 450
10	D)	4 400
20	E)	11 750
1	N.R.	

Option Topics

Table VI-2 presents mean score data on the option topics. The most popular options, Conic Sections, Binomial Theorem, and Permutations and Combinations, produced the highest results. The least popular options, Compound Interest, Circular Functions, and Sinusoidal Functions, produced the lowest results. It must be kept in mind that because of the optional nature of these topics, only parts of the selected sample chose specific topics. The scores represent neither the province nor individual strata. The data is presented for the benefit of those schools whose students wrote the items in the particular options.

Table VI-2

Mathematics 300: Results on Option Subtests

Option	Topic (item numbers)	Stratum*	n	Percent Correct
I.	Binomial Theorem (35 - 38)	1	158	43
		2	104	43
		3	44	64
		4	5	30
II.	Compound Interest (41-44)	1	16	30
		2	-	-
		3	-	-
		4	15	18
III.	Sinusoidal Functions (51-54)	1	3	33
		2	36	20
		3	-	-
		4	28	23
IV.	Circular Functions (61-64)	1	4	25
		2	7	14
		3	37	28
		4	8	22
V.	Permutations and Combinations (71-74)	1	172	46
		2	92	48
		3	44	58
		4	-	-
VI.	Conic Sections (81-84)	1	364	55
		2	84	31
		3	37	18
		4	-	-
VII.	Transformation of Conics (91-94)	1	117	45
		2	25	27
		3	-	-
		4	-	-

*Strata Definitions:
1 Urban
2 Rural/Small town
3 Other city/Large town
4 Remote/Northern

Recommendations

Generally the results on the 1987 Curriculum Assessment Test for Mathematics 300 were unsatisfactory. The following reasons were put forth as possible causes for the continued poor performance of our students:

(a) In 1981, the Final Report recommended that an in-depth look be taken at the time allotment for Mathematics 300. The time allotment was not changed.

(b) The Technical Advisory Committee believes that the increasingly diverse backgrounds of Mathematics 300 students has forced teachers to increase the amount of time spent on review and reteaching of pre-mathematics 300 concepts. It was felt that many students who enroll in Mathematics 300 are not able to cope with the rigors of the subject. In order to get a picture of those who enroll in Mathematics 300, the Technical Advisory Committee decided to review the percentage of grade 12 students who, over recent years, had enrolled in Mathematics 300 and 301. Unfortunately, the student Academic Record System does not have the information that would allow this question to be answered definitively. Information that is available indicates that, in an era of generally declining enrollments, the number of students receiving credits in Mathematics 301 has declined from 4338 in June, 1976 to 3162 in June, 1984, the last year for which records on credits granted are presently available. In the same time period, however, the number of students receiving Mathematics 300 credits has increased from 4622 to 5536. Enrollment data were available for the 1987-88 school year. These data also show an increasing number of students opting for Mathematics 300 (see Table VI-3 below). This unusual increase in Mathematics 300 lends some credibility to the assumption made by the T.A.C. that there has been a shift in enrollment from Mathematics 301 to Mathematics 300 and that this shift has resulted in some students entering a course for which they are ill-prepared. This increase in the number of students taking Mathematics 300 may be caused by school, parental, and general social pressures to keep academic doors open. Some post-secondary programs list Mathematics 300 as a required or recommended entrance requirement. Mathematics teachers, administrators, and school counsellors should provide the leadership in encouraging only students with at lease some hope of being successful in Mathematics 300 to enroll in such a mathematically demanding course.

Table VI-3

	Credits Granted		Students Enrolled*
Math	1976	1984	1988
301	4338	3162	3873
300	4622	5536	6404

* Data on credits granted are not yet available for this year.

(c) High school students may have had very little experience writing multiple choice test items. It may be that teachers are unfamiliar with this type of item construction.

(d) Since the test is not part of a student's final mark in mathematics, many students may not have put forth their best effort.

(e) In many semestered schools which offer Mathematics 305 courses, it may be that some of the best mathematics students did not write the Assessment test because they had enrolled in Mathematics 300 during the first semester.

(f) There is often a long time period for students, with its attendant problem of forgetting, between sequential courses. In semestered schools, students may take the 200 level course in the first semester of the year and will then take the 300 level course in the second semester of the following year.

The Technical Advisory Committee makes the following specific recommendations in regard to Mathematics 300:

RECOMMENDATIONS TO HIGH SCHOOL TEACHERS

Teachers are encouraged to make every effort to increase their students' mathematical vocabulary by constantly using correct and appropriate mathematical terminology. For example, students should know that the zeros of a function are also the x-intercepts of that function.

The Mathematics 300 course uses transformations as a foundational concept in the development of the various functions and relations that students study. If this approach is to be effective, it must be re-emphasized throughout the entire course. The results on questions which tested this concept, namely items 5, 14, and 24, suggest that transformations may require reinforcing. (Schools which use the transformational approach to the study of functions tend to introduce the approach in the earlier grades while developing linear and quadratic functions.)

RECOMMENDATIONS TO SCHOOL DIVISIONS

The low results in this curriculum assessment reveal that Mathematics 300 objectives were mastered by a minority of students. School divisions should ensure that sufficient time is available for teaching the entire course.

The counselling of students in Mathematics 300 should be examined to determine the reasons students are taking this course.

RECOMMENDATIONS TO MANITOBA EDUCATION

The counselling of students in Mathematics 300 should be examined. It may be that many students enroll in this course simply because it is one of the entrance requirements into a post secondary institution. Perhaps such institutions could be encouraged to use Mathematics 301 as their high school mathematics requirement where the content of Mathematics 300 is not required for the post secondary courses specifically.

The Technical Advisory Committee recommends that Manitoba Education reassess the idea of Math 300 option topics, as some topics are more essential than others for further mathematics study and therefore should be part of the core requirements.

The Technical Advisory Committee recommends that Manitoba Education develop and maintain the Student Academic Record System in such a way that analysis over time can be made on numbers of students enrolled and numbers of students who have successfully completed individual courses.

Manitoba Education should study the issue of low performance at the Mathematics 300 level and implement strategies to redress this problem.

RECOMMENDATIONS TO FACULTIES OF EDUCATION

The Faculties of Education should ensure that their student teachers are familiar with the variety of test item construction techniques.

Faculties of Education should encourage their teacher trainees to make every effort to increase their students' mathematical vocabulary by constantly using correct and appropriate mathematical terminology.

Faculties of Education should ensure that their student teachers recognize that the Mathematics 300 course uses transformations as a foundational concept in the development of the various functions and relations that are studied. The results on questions which tested this concept, namely items 5, 14, and 24, suggest that transformations require reinforcing. (Schools which use the transformational approach to the study of functions tend to introduce the approach in the earlier grades while developing linear and quadratic functions.)

Mathematics 301 Results

The Mathematics 301 Curriculum is divided into Core and Option sections. Each student in the sample of 25 schools with 542 students was required to write the Core Topic subtests and two Option Topic subtests designated by the teacher. The Core section contained a total of 30 items divided into four subtests. Each Option subtest contained 4 items.

The sample for the Option subtests is not representative because of the low numbers of students selecting any given option in certain strata. Therefore, it has not been possible to generalize the option results to the province as a whole. Hence provincial data is presented only for the Core Subtests and this is shown in Table VI-3. The Option Topics results are shown by strata in Table VI-4. More details, including item data for the Core section are available in the Preliminary Report.

Table VI-3

Mathematics 301: Results on Core Subtests

	Core Subtest	Item Numbers	No. of items	Percent Correct
C.I	Consumer Mathematics	1-10	10	68
C.II	Algebra	11-22	12	54
C.III	Trigonometry	23-26	4	51
C.IV	Statistics	27-30	4	50

C.I Consumer Mathematics

The overall performance of 68% correct on this topic was considered by the Technical Advisory Committee to be satisfactory. The results on two items pulled the total result down considerably. One of these items seems not to have been read carefully; over 45% of the respondents chose E, indicating that they did not calculate the monthly cost.

(2) The Health Department recommends that a family spends no more than 30% of its annual salary on housing. Daisy earns $15 000 a year at her present job. The most she should spend on housing for each month is

1%	A)	$ 312.50
36	*B)	$ 375.00
14	C)	$ 450.00
3	D)	$ 500.00
46	E)	$4 500.00

On the other hand, a number of financial items indicate that students are able to read financial tables (insurance and mortgage) and know some of the vocabulary of finance and taxes.

7 Use the table to answer the following question:

What is the annual payment on a term insurance policy of $50 000 for 15 years issued at age 18?

PREMIUM RATE TABLE
LIFE INSURANCE: ANNUAL PREMIUMS
(PER $1000 WORTH OF INSURANCE)

AGE AT ISSUE	TERM		WHOLE LIFE (TO AGE 85)	LIMITED-PAYMENT LIFE (TO AGE 65)	ENDOWMENT	
	10 YEARS	15 YEARS			TO AGE 60	TO AGE 65
15	$3.58	$4.08	$11.14	$11.82	$14.35	$14.98
16	3.64	4.10	11.48	12.21	14.85	15.86
17	3.70	4.13	11.82	12.60	15.34	16.74
18	3.76	4.15	12.16	12.99	15.84	17.62
19	3.83	4.17	12.50	13.38	16.34	18.50
20	3.90	4.20	12.84	13.77	16.84	19.37
21	3.96	4.22	13.25	14.26	17.48	20.17
22	4.02	4.24	13.66	14.75	18.13	20.97
23	4.09	4.26	14.07	15.24	18.78	21.77
24	4.16	4.28	14.48	15.73	19.45	22.57

4%	A)	$188.00
2	B)	$206.50
85	*C)	$207.50
6	D)	$208.50
2	E)	$225.50
1	N.R.	

C.II Algebra

The overall performance on the Algebra subtest was 54% correct, and the Technical Advisory Committee considered the performance on most of the items as satisfactory. A number of algebraic simplifications were well performed, but in the following item, the negative signs in the exponents were apparently ignored by almost half (46%) of the students.

12 Simplify completely

$$\frac{(2)^3(-5)^{-2}}{(10)^{-2}}$$

12%	A)	1
46	B)	2
34	*C)	32
5	D)	50
2	E)	10 000
1	N.R.	

The item was answered correctly by 34%. A weak performance was also apparent on item 19 which asked students to identify the graph of $y = 3x - 2$. Only 37% were able to do this correctly, but another 53% selected graphs with positive slopes.

Fifty-two percent were able to correctly solve for x in the equation $5x - 3(7x + 6) = 2x - 1$ (item 15). In solving a system of two linear equations in x and y, 51% were successful (item 17).

C.III Trigonometry

This subtest consisted of 4 items and overall performance was 51% correct. Just 64% were able to give the right triangle definition of the sine (item 23) and only 47% were able to find the measure of one of the acute angles of a right triangle (item 24), given the measures of all of the sides.

A problem requiring application of the law of sines (item 25) was answered correctly by 73% of the students; unfortunately, a judicious guess would have selected the correct response. A question that required the use of the law of cosines (item 26) was answered correctly by 21%, with no particular error pattern apparent.

C.IV Statistics

Seventy-seven percent of students were able to correctly calculate the mean of 10 numbers (item 27), and 56% could calculate the median of a set of 9 numbers (item 28). For a set of grouped data, 50% were able to identify the mode (item 29), while only 17% correctly determined the median (item 30).

Option Topics

The data for the Option Topics are presented in Table VI-4. Provincial data are not reported for the options because of the low numbers of students selecting any given option in certain strata. Stratum scores should be interpreted with caution since not all sample schools within a stratum chose the same options. Therefore, the data represent neither the province nor the strata. The data are included here for the benefit of those schools in the sample who selected the particular options.

A few comments are in order from the curricular perspective regarding the results for the Option topics. First, several topics, namely I, II, and III, are being selected by only a very small number of teachers. Indeed, Digital Logic was not selected at all and the Annuities subtest was written by only 20 students with a percent correct of 33%. Option II, Depreciation and Distribution of Overhead Costs, attracted less than 20% of our sample.

Those Options which seem to be attracting the most attention are Investments (IV), Interpretation of Graphs (V), Quadratic Equations (VI) and Permutations and Combinations (VII).

For those strata and options in which n>25, it is perhaps possible to make some sort of interpretation of results. The more traditional topics of graphs, quadratic equations, and permutations and combinations, along with statistics, all show sufficient participation in two or more strata. Only a few of these results are above 60%. In Options IV, VI, VII, and VIII all performances are below 50%.

Table VI-4

Mathematics 301: Results on Option Subtests

Option	Topic (item numbers)	Stratum*	n	Percent Correct
I	Annuities (31-34)	1	0	-
		2	20	33
		3	0	-
		4	0	-
II	Depreciation and Distribution of Overhead Costs (41-44)	1	0	-
		2	77	50
		3	0	-
		4	5	55
III	Digital Logic (51-54)	1 - 4	0	-
IV	Investments (61-64)	1	46	43
		2	96	61
		3	0	-
		4	4	25
V	Interpretation of Graphs (71-74)	1	118	50
		2	64	63
		3	24	66
		4	19	54
VI	Quadratic Equations (81-84)	1	171	25
		2	78	36
		3	70	22
		4	16	17
VII	Permutations and Combinations (91-94)	1	10	40
		2	72	38
		3	40	41
		4	0	-
VIII	Statistics (Standard Deviation and the Normal Curve) (101-104)	1	51	28
		2	41	12
		3	6	46
		4	0	

*Strata Definitions:
1 Urban
2 Rural/Small town
3 Other city/Large town
4 Remote/Northern

Recommendations

An assessment test gives an indication of the content covered and of typical performance on the learned curriculum. Students may have had little practice and training in writing multiple choice tests. From this perspective the overall performance on the Mathematics 301 Core Topics was considered satisfactory by the Technical Advisory Committee. The performance on Option Topics cannot easily be summarized. Several option topics were selected by only a few classes. This suggests that perhaps the curriculum needs continuous monitoring as to the topics available as options.

The following recommendations are made by the Technical Advisory Committee in regard to Mathematics 301:

RECOMMENDATIONS TO MANITOBA EDUCATION

That Manitoba Education re-assess the option topics to determine whether this part of the curriculum be revised. For example, Digital Logic is a very difficult option and very few teachers teach it.

RECOMMENDATION TO POST SECONDARY INSTITUTIONS

That consideration be given to making Mathematics 301 the mathematics admission requirement to post secondary institutions for programs not requiring the specific content of Mathematics 300. Appropriate counselling should complement such a change.

CHAPTER VII

A COMPARISON OF 1981 AND 1986 PERFORMANCE

In May, 1986 samples of students in grades 3, 6, 9, and 12 were administered the 1981 assessment tests in order to assess changes in performance over the five-year period. Of the groups originally tested in 1981, only Mathematics 301 students were not sampled because a new and quite different curriculum has been introduced in the meantime. The discussion of these comparison results will be done by grade level and topical areas subtest, indicating the most significant changes. While no tables are presented for the analysis by cognitive level, the same analyses were done as in 1981; only when such results are significantly different from 1981 or when they highlight other results, will they be mentioned. For the rest, the tables speak for themselves. More specific information on the 1981 results may be found in the Final Report and the preliminary reports for each grade level of the Manitoba Mathematics Assessment Program 1981.

At each grade level a stratified random sample of schools was selected for participation. The stratum used was geographic location.

Grade 3

The grade 3 sample consisted of 945 students in 29 schools scattered throughout Manitoba. The results of the 1986 and 1981 testing are shown in Table VII.1. Identical tests were used. Seven topical areas showed gains since 1981. Concepts of Whole Numbers, which was rated Very Satisfactory in 1981, improved still further in 1986. Of particular interest are those areas which were rated marginal or unsatisfactory in 1981 but which have shown significant improvement. This group includes: Division of Whole Numbers; Patterns; Area, Volume, and Capacity; and Money, Time, and Temperature. A recommendation was made in 1981 for more emphasis on measurement and thus the substantial improvement in that area is encouraging.

The Technical Advisory Committee views with some concern the four areas in which a decline was noted. This is particularly serious in a major topic such as Multiplication of Whole Numbers and in areas which were already identified as unsatisfactory in 1981, namely, Fractions and Decimals and Applications (Whole Number Operations). Thus the latter continues to be a very weak area despite calls for more emphasis in problem solving, a closely allied area.

Analyses of comparison results were also performed on subtests determined by cognitive level. Very few significant differences were found. Perhaps the most noteworthy were the indications of increased comprehension in both Geometry and Measurement.

Table VII-1

Topical Subtest Results for 1981 and 1986 - Grade 3

Subtest		No. of Items	Average[a] % Correct 1981	1986	Change[b] in %
I. NUMBER SYSTEMS, OPERATIONS AND PROPERTIES					
I.A	Concepts of Whole Numbers	3	82	84	+2
I.B	Place Value	6	74	72	-2
I.C1	Addition of Whole Numbers	8	78	78	
I.C2	Subtraction of Whole Numbers	7	63	62	
I.D1	Multiplication of Whole Numbers	12	79	74	-5
I.D2	Division of Whole Numbers	7	62	66	+4
I.E	Fractions and Decimals	4	52	51	-1
I.G	Patterns	6	62	64	+2
I.H	Applications	8	59	55	-4
II. MEASUREMENT					
II.A	Linear Measurement	12	70	72	+2
II.BC	Area, Volume, and Capacity	4	50	53	+3
II.EFG	Money, Time, and Temperature	7	59	60	+1
II.H	Applications	4	26	27	
III. GEOMETRY		9	75	76	+1
IV. GRAPHING		3	79	79	

[a] Average percent correct figures are rounded to the nearest whole percent.
[b] The change in percent correct for a subtest is given only when the difference in mean scores (average number correct) from 1981 to 1986 is statistically significant ($p<.05$).

Grade 6

A sample of 823 students in 28 schools in Manitoba was selected. The results for grade 6 are shown in Table VII-2. Significant improvement took place in only three topical subtests. The greatest gains were made in Place Value, Regrouping, and Rounding Off and in Measurement, which in 1981 had performance ratings of marginal and unsatisfactory respectively. Both of the areas had engendered recommendations for more attention in the 1981 report. Furthermore, Equalities and Inequalities improved on an already strong performance.

Table VII-2

Topical Subtest Results for 1981 and 1986 - Grade 6

Subtest		No. of Items	Average[a] % Correct 1981	1986	Change[b] in %
I. NUMBER SYSTEMS, OPERATIONS AND PROPERTIES					
I.ACD	Place Value, Regrouping and Rounding Off	8	64	69	+5
I.E	Equalities and Inequalities	4	86	88	+2
I.F	Patterns	1	42	49	
I.GH	Factors, and Prime and Composite Numbers	5	45	43	-2
I.J	Properties	5	87	82	-5
I.KL	Add. and Subt. of Whole Numbers	11	83	82	-1
I.M	Mult. of Whole Numbers	9	77	74	-3
I.N	Division of Whole Numbers	9	65	64	
I.OV	Fractions and Percent	8	61	60	
I.PQR	Operations with Fractions	10	57	50	-7
I.STU	Operations with Decimals	9	57	57	
II. MEASUREMENT		9	46	48	+2
III. GEOMETRY		6	50	50	
IV. GRAPHING		4	61	63	
I.W1	Word Problems - One Step	6	72	71	
I.W2	Word Problems - Two Step	6	62	57	-5

[a] Average percent correct figures are rounded to the nearest whole percent.
[b] The change in percent correct for a subtest is given only when the difference in mean scores (average number correct) from 1981 to 1986 is statistically significant ($p<.05$).

Declines were noted in six areas. Of most serious concern are the performances in Operations with Fractions and in Two Step Word Problems. The former is crucial to further progress in mathematics and comes on top of an only marginal performance rating in 1981, while problem solving has been strongly emphasized in the professional literature as well as in local workshops during this period. Recommendations are noted in both the "Grade 6 Results" and "The Teacher Survey" Chapters on these weaknesses.

Cognitive level subtests showed the level of performance at the Application level to be lower than that in 1981. This parallels the poorer 1986 performance in problem solving and applications problems in arithmetic.

Grade 9

The data for grade 9 are presented in Table VII-3. Overall the results for the grade 9 sample of 1091 students in 20 schools showed gains in most topic areas. These include Square Root; Angles and Parallel Lines; Algebraic Terminology; Equations; and Graphing, the performance in all of which were rated as either marginal or unsatisfactory in 1981. The Technical Advisory Committee views this as an encouraging result. Basic Operations and Exponents remain at approximately the same level of performance.

Only the subtest on Word Problems showed a significant decline in performance. This subtest admittedly represents a small sample of problem solving skills, but it has been tested over a large number of students thus providing good reliability. Given the current emphasis on problem solving, the Technical Advisory Committee found the results disappointing. Recommendations are stated in both the "Grade 9 Results" and "The Teacher Survey" Chapters concerning this issue.

Table VII-3

Topical Subtest Results for 1981 and 1986 - Grade 9

Subtest	No. of Items	Average[a] % Correct 1981	1986	Change[b] in %
I. NUMBER SYSTEMS, OPERATIONS AND PROPERTIES				
I.A1 Basic Operations	16	57	56	
I.A2 Order and Word Problem	4	63	65	+2
I.A3 Square Roots	5	47	51	+4
II. MEASUREMENT	3	53	58	+5
III. GEOMETRY				
III.A Basic Constructions				
III.B Angles and Parallel Lines	4	44	47	+3
IV. ALGEBRA				
IV.A1 Terminology	3	57	61	+4
IV.A2 Exponents	5	40	41	
IV.A3 Simplifications	11	57	59	+2
IV.A4 Substitutions	5	62	65	+3
IV.B Equations	14	53	56	+3
IV.C Word Problems	4	52	39	-13
V. GRAPHING AND STATISTICS				
V.A Arithmetic Mean	2	71	68	
V.B Graphing	3	55	59	+4

[a] [b] Average percent correct figures are rounded to the nearest whole percent. The change in percent correct for a subtest is given only when the difference in mean scores (average number correct) from 1981 to 1986 is statistically significant ($p<.05$).

Grade 12: The General Test

The Grade 12 General Test was administered in 1981 to a sample of all grade 12 students regardless of their enrollment in a grade 12 mathematics course. The results were analyzed separately for Mathematics 300 students, Mathematics 301 students and students who elected no grade 12 mathematics course. The analyses of the comparison with the 1981 results were carried out using the same groupings.

General Test: Students with no Grade 12 Mathematics

The sample of students not enrolled in a grade 12 course (the "Nonmath" group) numbered 329 in 15 schools. Results for this group are presented in Table VII-4. A significant decline in performance is noted in all areas except Geometry, which showed an improvement. The latter is certainly welcome in light of the unsatisfactory performance rating given to Geometry in 1981. However, the decline in all other areas including Basic Operations (unsatisfactory in 1981) and the great decline in the applications areas of Graphs and Statistics and Consumer problems (both satisfactory in 1981) is noteworthy. Cognitive level subtests were similarly all lower in 1986 than in 1981 except those analyzed specifically for geometry. The Technical Advisory Committee feels that for students entering the world of work this is not an encouraging picture.

Table VII-4

Topical Subtest Results for 1981 and 1986 - Grade 12

General Test: Students with no Grade 12 Mathematics

	Subtest	No. of Items	Average[a] % Correct 1981	1986	Change[b] in %
A.	Number Systems and Operations				
	A1 Basic Operations	9	55	52	-3
	A2 Ratios and interrelationships among fractions, decimals and percents	6	62	52	-10
B.	Measurement	4	87	80	-7
C.	Geometry	7	46	48	+2
D.	Algebraic Concepts	4	43	40	-3
E.	Graphs and Statistics	5	69	51	-18
F.	Consumer Applications	15	57	49	-8

[a] [b] Average percent correct figures are rounded to the nearest whole percent. The change in percent correct for a subtest is given only when the difference in mean scores (average number correct) from 1981 to 1986 is statistically significant ($p<.05$).

General Test: Students with Mathematics 301

The sample of Mathematics 301 students for the General Test was 227 in 13 schools. The figures presented in Table VII-5 speak for themselves. Performance in only a single area did not decline since 1981 -- performance in geometry remained constant -- while that in all other areas went down. Similar results were found when the data were analyzed by cognitive level.

Table VII-5

Topical Subtest Results for 1981 and 1986 - Grade 12

General Test: Students with Mathematics 301

	Subtest	No. of Items	Average[a] % Correct 1981	1986	Change[b] in %
A.	Number Systems and Operations				
	A1 Basic Operations	9	75	62	-13
	A2 Ratios and interrelationships among fractions, decimals and percents	6	73	63	-10
B.	Measurement	4	90	87	-3
C.	Geometry	7	59	57	
D.	Algebraic Concepts	4	61	53	-8
E.	Graphs and Statistics	5	77	57	-20
F.	Consumer Applications	15	67	61	-6

[a]

[b] Average percent correct figures are rounded to the nearest whole percent. The change in percent correct for a subtest is given only when the difference in mean scores (average number correct) from 1981 to 1986 is statistically significant ($p<.05$).

General Test: Students with Mathematics 300

The General test sample for students with Mathematics 300 consisted of 432 students in 14 schools. The results are presented in Table VII-6. Performance in all topical subtests except Measurement declined significantly since 1981. Means on the Measurement subtest were virtually identical, indicating no difference from 1981 to 1986. When analyzed by cognitive level gains are again shown only in the area of Measurement with declines shown in all other subtests at all three levels.

Table VII-6

Topical Subtest Results for 1981 and 1986 - Grade 12

General Test: Students with Mathematics 300

	Subtest	No. of Items	Average[a] % Correct 1981	1986	Change[b] in %
A.	Number Systems and Operations				
	A1 Basic Operations	9	91	84	-7
	A2 Ratios and interrelationships among fractions, decimals and percents	6	88	83	-5
B.	Measurement	4	94	94	
C.	Geometry	7	83	77	-6
D.	Algebraic Concepts	4	81	76	-5
E.	Graphs and Statistics	5	89	70	-19
F.	Consumer Applications	15	83	74	-9

[a] Average percent correct figures are rounded to the nearest whole percent.
[b] The change in percent correct for a subtest is given only when the difference in mean scores (average number correct) from 1981 to 1986 is statistically significant ($p<.05$).

General Test: Summary

The Technical Advisory Committee found the results disappointing. The only gain for any group over the 7 topical subtests was the Nonmath students' improved performance on Geometry items. Students with Mathematics 301 showed no change in Geometry, while students with Mathematics 300 showed a decline. In Measurement, Mathematics 300 students registered no gain, while the others declined in performance in this area. All other topical subtests showed declines. This should be of great concern to all of us in mathematics education.

The reasons for such a poor showing are not obvious. The sampling procedure has been examined to try to determine whether our sample is different in any significant way. While schools were sampled in 1986 and individuals in 1981, the stratification and random selection procedures should result in comparable samples. In some schools, the 1986 procedure may have resulted in tighter control and a more representative cross-section of pupils writing. In 1981 in some schools it may have been easier for uninterested students just to walk away and not write the test. However, about the same proportion of the designated sample wrote the test in each year. That there are real differences here as a result of sampling procedures is definitely speculative and there are likely other factors which contribute to the differences in performance.

Mathematics 301

No comparison was made for the Mathematics 301 course because the curriculum has been significantly changed since 1981. The new curriculum places greater emphasis on consumer applications and financial mathematics.

Mathematics 300

The sample for Mathematics 300 consisted of 374 students in 12 schools who were enrolled in the course in the spring term 1986. The test was administered at the same point in the term in both years. Because of changes in the curriculum it was decided not to compare performance in the areas of Systems of Equations and Inequalities, resulting in seven areas being tested. Note that the area of Permutations, Combinations, and Binomial Theorem is an option in the new curriculum. It was selected by slightly less than half of the students writing in the 1987 assessment and there is no reason to believe that the proportion choosing this topic would have been any less in 1986. The data are shown in Table VII-7.

Improvement in performance is manifested in two areas, namely Exponential and Logarithmic Functions and Progressions. The topic of Circular Functions showed no significant change and the four other areas showed a decline in performance. In 1981 only one area, Permutations, Combinations, and Binomial Theorem, was rated very satisfactory; all others were rated either satisfactory or marginal. Thus in one area (Relations and Functions) previously rated marginal, performance has declined still further, while in others it has declined from what was a satisfactory rating.

In other words, a generally poor to mediocre performance in 1981 has declined even further in 1986. It was suggested in 1981 that perhaps the fact that hand-held calculators were not permitted was a factor in poor performance -- not because students could not calculate properly, but because it forced the format of many of the multiple choice answers and distractors. This could be one of many factors affecting performance.

Table VII-7

Topical Subtest Results for 1981 and 1986 - Grade 12
Mathematics 300

	Subtest	No. of Items	Average[a] % Correct 1981	1986	Change[b] in %
A.	Relations and Functions	9	54	51	-3
B.	Exponential and Logarithmic Functions	6	51	54	+3
C.	Circular Functions	6	50	52	
D.	Trigonometric Identities	3	41	35	-6
E.	Trigonometry	5	53	49	-6
F.	Systems of Equations	2	}	Not tested	
G.	Inequalities	3	}	in 1986.	
H.	Progressions	3	44	47	+3
I.	Permutations, Combinations, and Binomial Theorem	5	61	40	-21

[a] Average percent correct figures are rounded to the nearest whole percent.
[b] The change in percent correct for a subtest is given only when the difference in mean scores (average number correct) from 1981 to 1986 is statistically significant ($p<.05$).

Conclusions

In summary, the comparison results for grades 3 and 6 suggest little overall change in performance, with a few areas slightly up and a few slightly down from 1981. In grade 3 seven areas were up, and four were down. At grade 6 a few more declines than advances were noted. In particular, operations with fractions and two-step word problems was down.

At grade 9, only the performance on word problems declined. All other areas either stayed the same (3 subtests) or improved (9 subtests).

At the grade 12 level, results on the General Test were, with only three minor exceptions, significantly lower in all areas for all groups. In Mathematics 300 three areas showed the same or increased performance, while three areas (excluding Permutations & Combinations) showed declines.

The TAC was concerned that the grade 12 general test results were so much lower in 1986 than they were in 1981. One reason sometimes advanced for this situation is that greater calculator use has translated into lower skill levels in arithmetic; however, results from a subtest which requires very little general arithmetic, "Graphs and Statistics" demonstrated the greatest declines in mean scores (about 19%).

Recommendations

It is recommended that Manitoba Education studies the issue of low general arithmetic skill levels of Manitoba high school students and implements appropriate strategies to redress this problem.

CHAPTER VIII

THE TEACHER SURVEY

The teacher survey was designed to collect information which would assist in the general interpretation of the student assessment tests and be of value to curriculum development committees and teacher educators in establishing goals with respect to new and ongoing programs, availability of resources, and inservice professional development. Such factors as time spent on various activities in the classroom, the availability of materials, the degree of implementation of curriculum guides, the availability of calculators and computers, and teacher attitudes and opinions should be considered when attempting to interpret the assessment results. The data and its analysis will not provide cause-and-effect relationships, but give a cross section of teacher views. The general information obtained will not explain specific student results, but does establish generalities regarding programs.

A sample of teachers of mathematics in each of grades 3, 6, 9, and 12 was surveyed. This chapter presents a summary of the survey findings for each grade level. Recommendations based upon this data are found at the conclusion of the chapter. The detailed data from the questionnaires are not given here; they are available from the Assessment Section, Manitoba Education.

The Survey

The survey consisted of four questionnaires, one for each grade level. The questionnaires were designed to assess teacher practices and opinions in a number of areas which differed in specifics by grade level. All questionnaire items fall into one of the following six categories:

Demographic and Classroom Organization Data. This includes present and past teaching experiences, how many classes are taught, classroom organization and, at the grade 9 and grade 12 levels, which of these classes are in a semester system.

Learning Activities. Items in this category identify those types of learning activities which receive emphasis.

Use of Calculators and Computers. This series of items attempts to ascertain the ways in which calculators and computers are used in the teaching of mathematics, and whether or not there is explicit instruction in the use of these tools.

Use of Guides, Texts, and Resource Materials. This series of items asks for teacher views on the usefulness of various resource materials, including Curriculum Guides, textbooks, teachers' guides, concrete materials, and the like. For courses in which option topics are part of the curriculum presented in the Guide, teachers were asked to indicate which options were being taught.

Student Evaluation. This section sought to determine teacher practices in the area of student evaluation.

Curriculum and Instruction - Your Views. This section provided an opportunity for teachers to express their views on certain aspects of the curriculum and instruction with which they deal. Views were sought on particular aspects of the curriculum topics and sequence as well as on such organizational matters as the semester system. Space was provided for teachers to make additional comments.

During the development of the questionnaire input was considered from the Technical Advisory Committee, the Contract Team, the Joint Committee on Evaluation, and the Mathematics Steering Committee. The questionnaires were sent to teachers in May 1987. The number of returned questionnaires and the percent return are presented in Table VIII-1. The instruments were self-administered and strict confidentiality was maintained. Results were analyzed for the Province as a whole with no individuals, schools or school divisions being identified.

Table VIII-1

Number and Percent of Returned Questionnaires

Grade Level	Number	Percent
3	243	82%
6	220	77
9	200	78
12 - 300	78	88
12 - 301	73	88

Survey results will be discussed by the six categories for grades 3 and 6 together, grade 9, and grade 12.

SURVEY RESULTS: GRADES 3 AND 6

A total of 243 grade 3 teachers and 220 grade 6 teachers returned questionnaires. This represents a sampling of teachers at these grade levels from across the province. The questionnaires for the two grade levels are parallel.

Demographic and Classroom Organizational Data

In both grades about one-fourth of the teachers were new to the grade level, and the remainder have longer experience teaching at their respective level. About 75% of the grade 6 teachers and 68% of the grade 3 teachers are in

single grade classrooms and over 80% of all teachers indicate that they teach mathematics 3 1/2 or more hours per week. On the other hand, about 15% of students receive 3 hours or less of mathematics instruction per week (Manitoba Education recommends 3 3/4 hours per week). While total group instruction is the most commonly used organization, both individual and small group instruction are used several times a month or more often by over 90% of teachers at each level.

Classroom Activities

Approximately 40% of grade 3 teachers use concrete materials in their teaching several times per month and 50% use them several times per week; this drops to 54% and 15% respectively at the at the grade 6 level. Activity centres are also more frequently used in grade 3 than in grade 6. In grade 6 there is an increased use of homework with about 30% assigning homework several times a month and 50% assigning homework several times per week; these figures are 33% and 14% respectively for grade 3. In other classroom activities there are only slight differences between the two levels, with greater use of textbook exercises at grade 6.

Use of Calculators and Computers

In grade 3 about 95% of the teachers indicated that calculators are sometimes permitted, whereas in grade 6 only 50% responded in this way and the remainder indicated that they are never permitted. Over half of the teachers in each grade did not report the kinds of activities for which they are using calculators. Indeed, at the grade 3 level, the data suggest that 75% of the teachers use the calculator but not for any organized learning activities. Only 33% of grade 6 teachers and 14% of grade 3 teachers stated that they provided explicit instruction in the use of the calculator. Between 10% and 15% of grade 3 teachers have students use calculators for each of the following activities: problem solving, arithmetic computation, checking answers, teaching concepts, and motivational activities. At the grade 6 level this increases to about 40% of teachers.

About 95% of the teachers in the two grades indicated that there were computers in their schools, and about 70% said that a computer awareness program is taught in their classes. One quarter of the teachers at each level said that the computer was being used at least several times monthly in their mathematics teaching. While drill and practice were the most common uses, other types of software and activities were in evidence.

Use of Guides, Texts, and Resource Material

At each level over 80% found the Curriculum Guide to be moderately to very useful in their planning and preparation. Materials from Manitoba Education, school divisions, and professional journals were found to be slightly to moderately useful by about 75% of the teachers. Resource books, textbooks, and teachers' guides to texts were found to be somewhat to very useful by about 90% of teachers. Ideas and materials from Manitoba Education library/film resources and from university courses were rated by most teachers to be slightly to not at all useful.

One-half of the teachers at each level used one basic textbook. Another 40% used two textbooks, but one predominantly.

Student Evaluation

Most evaluation for both instructional planning and grading purposes is based on teacher prepared tests and observations of daily work. About half of the teachers made some use of commercial tests designed to be used with particular textbooks. School division tests were not available in many cases, and were used by less than 25% of the teachers. Similar patterns were observed at the two levels.

Curriculum and Instruction - Your Views

Over 75% of the teachers at each level agreed that problem solving should receive major emphasis. Furthermore, they disagreed with the views that computation with fractions and computation with decimals should be removed from the elementary school and be entirely taught at the junior high level. They also disagreed with the idea that addition and subtraction of integers (signed numbers) be taught at the elementary level.

A final questionnaire item asked respondents to check those areas in which they would like to see inservice or professional development activities. While the percents vary slightly, the rank ordering of the topics was almost identical for the two grade levels. A listing of all areas checked by approximately 40% or more at each level follows:

1. teaching problem solving
2. enrichment mathematics
3. using computers in teaching mathematics
4. manipulative materials
5. remediation in mathematics
6. teaching methods in mathematics
6. using calculators in teaching math (grade 6 only)

SURVEY RESULTS: GRADE 9

A total of 200 grade 9 mathematics teachers from across the province returned questionnaires. This is a sample of all grade 9 mathematics teachers.

Demographic and Classroom Organizational Data

Approximately 80% of the teachers have been teaching grade 9 mathematics for two or more years and many of these have also taught grades 7 and 8 mathematics. However, only half of these teachers teach mathematics 50% or more of their teaching time. In other words, the remainder of the teachers are teaching other subjects 50% or more of the time. About one-quarter of the sampled grade 9 teachers have had no university level courses in mathematics, and one-half have one or two university level courses in the subject. Approximately 70% have attended two or more mathematics inservices during the last three years.

A single grade level in the classroom is the norm for 80% of the teachers, and about half of these classes are heterogeneously grouped, i.e., not streamed. The semester system is used in about 20% of the grade 9 classes. Total group instruction predominates, but about 75% of teachers indicated that they also use individual and small group instruction.

Classroom Activities

Concrete materials are used infrequently by grade 9 teachers. Total group teacher explanations/demonstrations are used by over 80% of teachers almost daily. Individual work and homework also occur several times per week as does the solving of textbook exercises.

Use of Calculators and Computers

Calculators are permitted sometimes or often by almost 80% of the teachers, with the most common uses being for problem solving, arithmetic computation, checking answers, and motivational activities. Explicit instruction in how to use the calculator is provided by 41% of teachers.

Computers are present in about 95% of the schools, with 77% of the teachers indicating that they are accessible for grade 9 students. A computer awareness program is taught in 66% of the schools. Over 50% of the teachers indicate that computers are never used to teach mathematics, although about 15% use computers several times per month and another 15% - 20% use them in various ways one or two times per year.

Use of Guides, Texts, and Resource Materials

Approximately 60% of grade 9 teachers find the current Guide moderately or very useful, while 20% find it only somewhat useful or not useful at all. Mathematics textbooks are the most useful resource item with teacher's guides to these texts a close second. Materials obtained through inservices and workshops were found to be very useful by 50% of the teachers. In approximately half of the classes one basic text is used, while in another 30% two texts are used, but one predominantly. No textbook is used by 12%.

The Curriculum Guide for Grade 9 specifies the selection of 3 option topics from a list of 5. Teachers were asked which of these topics they chose and it is clear from their responses that many choose parts from several options. The entire Algebra option (a core topic in the French Guide) was selected by 67%, with another 22% electing to do part of it. In Geometry 41% indicated that they teach the whole unit and 42% do part of it. In Coordinate Graphing 46% do the entire unit and 32% do part. Statistics is the least popular option with only 9% teaching the entire unit and 21% doing part of it.

Student Evaluation

Teacher prepared tests, daily evaluation of student work and daily observation of students work habits are used by over 80% of teachers for both planning and grading purposes. Results on commercial tests, either standardized or those keyed to particular texts are used by about 20% of teachers for instructional planning. Standardized test results are used by fewer than 7% for purposes of grading.

Curriculum and Instruction - Your Views

As in the grade 12 questionnaire (see below) grade 9 teachers were asked their view on mathematics learning in the semester system. In regard to student motivation, 47% favored the full-year system, 17% favored the semester system, and the remainder had no opinion. For each of the following factors, over 60% favored the full-year system and less than 8% favored the semester system: more student learning time, more student homework time, more content coverage, and better learning generally.

Three-quarters of the grade 9 teachers favored a continued emphasis on problem solving. Over 50% disagreed that computation with decimals and fractions should be removed from the elementary program and be taught entirely at the junior high school level. Similarly they did not wish addition and subtraction of integers to be moved into the elementary from junior high. About 56% of the teachers indicated that more instructional time should be available for mathematics.

A final questionnaire item asked respondents to indicate area in which they would like to see inservice or professional development activities. Each item in the following rank ordered list was checked by approximately 50% or more of the teachers:

1. remediation
2. enrichment mathematics
3. teaching problem solving
4. using computers in teaching mathematics
5. teaching methods in mathematics

SURVEY RESULTS: GRADE 12

A total of 151 grade 12 teachers of Mathematics 300 or 301 responded to the survey. A given teacher completed only one of these questionnaires. The questionnaires for the two courses were parallel, with only slight differences to reflect the distinctive features of the courses. They will be discussed together.

Demographic and Classroom Organization Data

Most of the teachers surveyed had teaching experience in the junior high school as well as in their present positions and well over half of them teach a wide variety of high school mathematics courses in both the "00" and "01" streams. Fewer than one-third of the Mathematics 300 teachers have taught Mathematics 305. About half of the teachers teach mathematics full time and over 70% teach math 60% time or more. Almost 70% of the Mathematics 300 teachers and 43% of the Mathematics 301 teachers have a university major in mathematics. Most of the teachers indicated that they had attended a math inservice program in the last 3 years.

Approximately 60% of the respondents are teaching in schools organized on a full year as opposed to a semester system. The norm in this system is about 3.5 hours of instruction per week or 136 hours for a 36 week year. Under the

semester system the norm is about 6 hours per week or 108 hours for 18 weeks of classes. Roughly 15% of those in the semester system are receiving less than this. Most schools teach Mathematics 300 and Mathematics 301 students in different classrooms. About 11% of the schools award Mathematics 301 credits for attendance in Mathematics 300. There are no data available that explain this phenomenon. Since the two courses are very different in content, it is an ill-advised procedure. The high school program requirements stipulate a minimum of 110 hours of instruction before credit can be given for a specific course.

Learning Activities

Most grade 12 mathematics students appear to spend much of their in-class time attending to lectures and demonstrations. Concrete materials are seldom used and about half of the teachers indicated that they occasionally provided enrichment activities and nonroutine problems. Problems from homework are taken up often or very often by 90% of teachers. Only in the assignment of homework did the two grade 12 courses appear to differ in this category. Mathematics 300 teachers assigned homework often (32%) or very often (66%), while in Mathematics 301 only 75% assigned homework often or very often. In Mathematics 300 82% of teachers indicated that students completed the assignments often or very often and in Mathematics 301 69% was indicated.

Use of Calculators and Computers

Calculators are widely used in both courses for the entire range of computational activities and to find logarithmic and trigonometric values. About half of the teachers indicated that they were often used in the development of new concepts. Explicit instruction in calculator use was provided by approximately 85% of the teachers.

Well over half of the teachers of each course indicated that computers are accessible in their schools. Furthermore, while over 65% indicated that a computer awareness course was available in their school and that programming is a part of this course, teachers in large numbers (over 60%) perceive that less than one-third of their students had any programming experience. Whether or not students are computer capable, 85% of Mathematics 300 teachers and 75% of Mathematics 301 teachers stated that they never used computers for instructional purposes.

Use of Guides, Texts, and Resource Material

The Provincial Curriculum Guide for grade 12 was found to be moderately useful or very useful by 80% and 75% of the teachers respectively in Mathematics 300 and Mathematics 301. In the former course the textbook is relied upon heavily with 90% indicating it to be moderately or very useful. Seventy-eight percent indicated that students use a single basic text most of the time although 33% said that other texts are available. Professional journals, ideas on materials obtained through university courses, school division materials, and resource books were identified as somewhat useful, while other materials were generally not useful.

The selection of option topics by Mathematics 300 instructors is shown in Table VIII-2. The Curriculum Guides mandates the selection of the equivalent of two modules of option topics. It is evident from this data that large numbers of teachers are selecting parts of options. Thus it is likely that

many students learn parts of these options, but are not likely covering the topic in depth. It is known that in some school divisions, no option topics are selected. On the other hand, data in the table suggest that some teachers are covering more than the required two options. Again the depth of this coverage must be questioned.

In Mathematics 301 no textbook is required. Teachers find a variety of resource materials useful, including various texts. Two and one-half modules of option topics are specified in this course and the data in Table VIII-3 suggest that many teachers are doing at least 3 modules. These data also confirm the representativeness of the sample of option tests in the student data. Digital Logic is seldom chosen and Interpretation of Graphs and Quadratic Equations are the most popular options.

Table VIII-2

Mathematics 300: Percent of Teachers Selecting Option Topics

Option	Topic	All	Part	None	No Response
I.	Binomial Theorem	62	10	18	10
II.	Compound Interest	9	61	18	13
III.	Graphs of Sinusoidal Functions	27	33	29	11
IV.	Circular Functions of Two Angles	41	29	19	11
V.	Permutations and Combinations	57	8	23	13
VI.	Conic Sections in Standard Position	65	20	9	6
VII.	Transformations of Conics	39	20	23	18

Table VIII-3

Mathematics 301: Percent of Teachers Selection Option Topics

Option	Topic	All	Part	None	No Response
I.	Annuities	30	26	19	23
II.	Depreciation	21	18	32	29
III.	Digital Logic	3	2	56	38
IV.	Investments	26	37	14	22
V.	Interpretation of Graphs	52	26	8	14
VI.	Quadratic Equations	62	22	8	8
VII.	Permutations and Combinations	38	18	18	26
VIII.	Statistics	51	27	12	10

Student Evaluation

In this section teachers were asked to indicate which varieties of assessment they find most useful (a) for purposes of instructional planning and (b) for purposes of grading. There was little difference in the responses of teachers in the two courses. Those things that teachers found most useful for planning purposes included teacher prepared classroom tests, teacher evaluation of student daily work, and teacher observation of day-to-day working habits. The same items with the addition of teacher evaluation of student projects were used by teachers in grading students.

Curriculum and Instruction - Your Views

The final section of the grade 12 questionnaires asked for teachers' opinions on a number of issues including the semester system and curricular issues. Identical questions on the semester system were asked in 1981. The 1987 data are presented in Table VIII-4

Table VIII-4

Grade 12 Teachers' Views on Mathematics Learning in the Semester System

		Full-Year	Percent Semester	No Difference	No Opinion
Better student motivation	300	33	32	17	19
	301	33	38	8	21
More student learning time	300	80	4	8	8
	301	66	14	11	10
More student homework time	300	70	11	10	9
	301	55	19	11	14
More content coverage	300	77	2	11	9
	301	62	14	12	12
Better learning generally	300	67	8	11	13
	301	60	18	10	12

In 1987 the data even more strongly indicate that teachers see more learning taking place in the full-year system as opposed to the semester system. Only in the area of student motivation is there some balance between the views on the two systems. The time available to teachers under the full-year system is demonstrably more.

Almost half of the grade 12 teachers felt that all grade 12 students should write a "common, middle school level competency examination in mathematics for graduation." The majority indicated that options should not be abolished in Mathematics 301. On the other hand, the results on a parallel item for Mathematics 300 suggested a 50-50 split as to whether all of Mathematics 300 should be compulsory (without options). Over half of the teachers thought a grade 12 mathematics course should be required for all students. Approximately 70% of Mathematics 300 teachers preferred the full-year system to the semester system for their course; among Mathematics 301 teachers 43% indicated a preference for the full-year system, while 33% preferred semestering.

A final series of questionnaire items asked teachers their views on topics that might receive more emphasis in the "01" program. Those that received the highest rankings from the grade 12 teachers were algebra, job skills, life skills, and problem solving. It is interesting to note that 70% of teachers felt that the Curriculum Guide should place more emphasis on problem solving techniques. The topics receiving least attention were geometry and statistics. In the middle range (40% - 50%) were vocational mathematics, arithmetic, computer awareness, and trigonometry.

Conclusions and Recommendations

Grades 3 and 6

The organizational aspects of teaching at these grade levels has changed little since the 1981 survey. Most teachers teach in single grade, self-contained classrooms. Individual, small-and large-group instruction are all used. Concrete materials appear to be widely employed, but their use decreases at the higher grade level. Calculators are used in limited ways at both grade levels, but explicit instruction in their use is infrequent. The Curriculum Guide and supplementary materials from Manitoba Education are widely used. Teachers also indicated a number of areas in which professional development activity is desired.

The following recommendations are made by the Technical Advisory Committee in regard to the elementary grades:

RECOMMENDATIONS TO TEACHERS

That calculator use be encouraged and that explicit instruction in the use of the calculator be provided to students.

That the use of activity centres be included in the mathematics program to provide motivation as well as reinforcement.

That mathematics be taught at least the recommended number of minutes per day (i.e., 45).

RECOMMENDATIONS TO SCHOOL DIVISIONS

That work with calculators be included in mathematics programs and that explicit instructions be provided to students in the use of the calculator.

That teachers be provided with appropriate materials and professional development to teach measurement (length, area, volume, and capacity).

That professional development be provided in the following areas:

1. **teaching problem solving**
2. **enrichment mathematics**
3. **using computers in teaching mathematics**
4. **manipulative materials**
5. **remediation in mathematics**
6. **teaching methods in mathematics**
6. **using calculators in teaching mathematics (grade 6)**

That the use of activity centres be included in the mathematics program to provide motivation as well as reinforcement.

That mathematics be taught at least the recommended number of minutes per day (i.e., 45).

RECOMMENDATIONS TO MANITOBA EDUCATION

That work with calculators be included in any future elementary mathematics curriculum guide. That explicit instruction in the use of calculators be provided.

That professional development be provided in the following areas:

1. **teaching problem solving**
2. **enrichment mathematics**
3. **using computers in teaching mathematics**
4. **manipulative materials**
5. **remediation in mathematics**
6. **teaching methods in mathematics**
6. **using calculators in teaching mathematics (grade 6)**
7. **teaching of measurement**

Grade 9

A single grade in the classroom is the norm for most grade 9 mathematics classes, and about half of these are heterogeneously grouped. Only about one-half (down from 60% in 1981) of grade 9 teachers teach at least half their load in mathematics. One-half of the teachers have two or fewer university courses in mathematics; 25% have none. About 70% of the teachers have attended two or more math inservice programs over the last three years. Total group explanations and demonstrations are used daily in most classes and the majority follow a single textbook. Calculators are used frequently, but computers infrequently. The Curriculum Guide is widely used as are materials from inservice programs. Teachers also indicated a number of areas in which professional development activity is desired.

As a result of these findings coupled with student performance, the Technical Advisory Committee makes the following recommendations.

RECOMMENDATIONS TO TEACHERS

That work with calculators and computers become an integral part of the grade 9 school curriculum.

That the topics of estimation and problem solving be given renewed emphasis.

RECOMMENDATIONS TO SCHOOL DIVISIONS

That school division superintendents ensure that grade 9 mathematics teachers have an adequate professional and academic background for their teaching assignments.

That work with calculators and computers become an integral part of the grade 9 school curriculum.

That the topics of estimation and problem solving be given renewed emphasis in the grade 9 program.

That professional development be provided in the areas of need indicated by grade 9 teachers, namely,

1. **remediation**
2. **enrichment mathematics**
3. **teaching problem solving**
4. **using computers in teaching mathematics**
5. **teaching methods in mathematics.**

RECOMMENDATIONS TO MANITOBA EDUCATION

That work with calculators and computers become an integral part of the grade 9 program.

That estimation and problem solving be given renewed emphasis in the grade 9 curriculum.

That professional development be provided in the areas of need indicated by grade 9 teachers, namely,

1. **remediation**
2. **enrichment mathematics**
3. **teaching problem solving**
4. **using computers in teaching mathematics**
5. **teaching methods in mathematics.**

That consideration be given to modifying the curriculum guide for grade 9, to include the topics noted in these recommendations.

That Manitoba Education encourage school divisions to assign teachers with an adequate background for their teaching assignments.

That Manitoba Education encourage the introduction of upgrading or refresher courses for teachers of junior high mathematics.

RECOMMENDATIONS TO FACULTIES OF EDUCATION

That consideration be given to the issue of providing refresher or upgrading courses to teachers of junior high mathematics.

Grade 12

In terms of classroom learning activities, evaluation practices and the use of various text and resource material the overall picture in 1987 is similar to 1981. Likewise, demographic and organizational aspects appear not to have changed. Calculators have won full acceptance in the grade 12 programs, although computers are little used in mathematics instruction despite their availability. On the question of the semester system for learning mathematics, the statement of teachers is even more strongly in favor of the full year system than in the 1981 survey.

It is clear that teachers in both of the grade 12 courses are electing to teach parts of option topics. That is, rather than teach a number of complete options as suggested by the Guide, parts of these modules are being taught.

The following recommendations are made by the Technical Advisory Committee:

RECOMMENDATION TO SCHOOL DIVISIONS

That school divisions ensure that sufficient time is available so that teachers are able to teach the entire mathematics curriculum.

School division superintendents should ensure that schools do not grant Mathematics 301 credits to students who have been enrolled in Mathematics 300 and for some reason will not be issued Mathematics 300 credits.

That school divisions determine and provide for the professional development needs of their high school mathematics teachers.

RECOMMENDATION TO MANITOBA EDUCATION

That the core/option format and the designation of particular topics as "options" in the grade 12 programs be examined. [See recommendations on pages 64 and 70 in Chapter VI.]

CHAPTER IX

CONCLUSIONS AND RECOMMENDATIONS

The intent of the mathematics assessment program was to provide provincial data on student achievement of the mathematics curriculum and data from teachers of mathematics on their classroom practices and views. These results and the consequent recommendations provided by the Technical Advisory Committee (TAC) are made available through this report to all of those concerned with mathematics education. This chapter provides a condensation of the conclusions for each test administered at the four grade levels and for the teacher survey. The recommendations included are based on a synthesis of the data from the different sources.

General Comments

The assessment provides direction to mathematics education in the province. While conclusions and recommendations for each grade level tested are presented in the following pages, there are certain issues that reappeared at different grade levels. The most common recurring issue was that modifications should be made to the curriculum. At the grade 3, 6, and 9 levels, the modifications recommended relate to problem solving, estimation, and the use of calculators and computers in the classroom. Both the grade 9 and 12 sections of the Technical Advisory Committee proposed that Manitoba Education should study the issue of options in those programs. This is not to say that there has been a call for the revamping of the entire curriculum: there were instead suggestions that certain refinements should be made which would reflect changing technology and changed emphases.

Perhaps the most surprising findings in the entire assessment were the results of the grade 12 general mathematics comparison tests. Declines from 1981 were noted in virtually all subtests for all grade 12 groups (Mathematics 300 and 301 as well as for the group that has taken no grade 12 mathematics). A recommendation relating to the study of this issue has been made. Lower performance levels in applications and problem solving at the other grade levels were also a concern to the Technical Advisory Committee, especially since there has been such an emphasis on problem solving in mathematics education in recent years.

Student Achievement

Grade 3

Overall performance on the assessment was considered by the TAC to be satisfactory. The two subtests on Problem Solving and Estimation were the weakest areas. Place value and basic operations with whole numbers were generally well done. Performance in Measurement, Geometry, and Graphing were all rated satisfactory. Nonroutine problem solving was a new area for assessment; results here were considered satisfactory at this time.

In the comparison of 1981 and 1986 data there were few great differences. Results in whole number division improved, although performance in multiplication declined slightly. Performance in measurement, rated unsatisfactory in 1981, showed encouraging gains. Work with fractions continues to be an area of some difficulty.

Grade 6

The Technical Advisory Committee considered overall performance at the grade 6 level to be satisfactory. The two weakest areas were operations with decimals and operations with fractions. In general, computation with whole numbers was adequately done, including its application in routine word problems. Results on nonroutine problem solving indicate difficulties and suggest that more emphasis is required. Computational estimation is increasingly important in mathematics and it is a concept that appears to be poorly understood.

Comparison of 1981 and 1986 data reveals overall performance to be about the same, but there are a few noteworthy discrepancies. Skills in place value and rounding off have improved, while performance in operations with fractions and two-step word problems have declined significantly. This latter result is of some concern to the TAC especially in view of the low performance in this area on the 1987 test as well.

Grade 9

Overall performance by grade 9 students as well as performance in each of the individual subtests was found by the Technical Advisory Committee to be satisfactory. A number of specific concerns are noted in Chapter V, including the importance of estimation and the role of the calculator in grade 9 mathematics. Performance in nonroutine problem solving is at a low, but not unexpected level at this time. Continued emphasis in this area is suggested. Almost all grade 9 classes tested elected to write the Algebra option which suggests that it is being widely taught (it is designated core in the French program). Geometry and Consumer Related Topics were each chosen by about 25% of the classes. The statistics option was virtually ignored.

Performance in 1986 improved over that in 1981 in a number of areas: Square Root; Angles and Parallel Lines; Algebraic Terminology; Equations; and Graphing. Only the subtest on Word Problems showed a significant decline in performance. Given the current emphasis on problem solving, the TAC found this comparison result disappointing.

Grade 12

Generally the results for Mathematics 300 were considered by the Technical Advisory Committee to be unsatisfactory. The Core areas considered satisfactory include parts of Analytic Geometry and some algebraic items. The subtests rated unsatisfactory by the TAC were: Circular Functions, Exponents and Logarithms, and Sequences and Series. The performance on all of the Option topics was considered weak, with the least popular options exhibiting the weakest performances.

In the 1981-1986 comparison testing slight increases in performance appeared in Exponential and Logarithmic Functions and in Progressions. Declines of some concern were noted in three areas, namely, Trigonometry, Trigonometric Identities, and Relations and Functions. Performance in the latter area was rated mediocre in 1981.

On the General Mathematics Test written in both 1981 and 1986, Mathematics 300 students exhibited a (statistically significant) lower performance on every subtest in 1986. Similar declines were noted for Mathematics 301 students, and for those with no grade 12 mathematics.

No comparison test was written in 1986 in Mathematics 301 because of the implementation since 1981 of an entirely new curriculum.

In 1987 the overall performance in Mathematics 301 was considered by the TAC to be satisfactory. There were some weaknesses in the Algebra and Trigonometry sections, but otherwise the Core topics were satisfactory. The data on Option topics were more difficult to interpret because of the small number of students in some strata (refer to Chapter VI). Where interpretation is possible the good performance in Interpretation of Graphs is to be noted. On the other hand, performances in the following option areas were considered by the TAC to be unsatisfactory: Investments, Quadratic Equations, Permutations and Combinations, and Statistics.

The Teacher Survey

Grades 3 and 6

The organizational aspects of teaching at these grade levels has changed little since the 1981 survey. Most teachers teach in single grade, self-contained classrooms. Individual, small and large-group instruction are all used. Concrete materials appear to be widely employed, but their use decreases at the higher grade level. Calculators are used in limited ways at both grade levels, but explicit instruction in their use is infrequent. The Manitoba Curriculum Guide and supplementary materials from Manitoba Education are widely used. Teachers indicated a number of areas in which professional development activity is desired.

Grade 9

A single grade classroom is the norm for grade 9 classes, with about half of these heterogeneously grouped. Only about one-half (down from 60% in 1981) of grade 9 teachers have half of their teaching load in mathematics. Furthermore, one-half of the grade 9 mathematics teachers have two or fewer university courses in mathematics; 25% have none. The importance of teacher background, both professional and academic, should not be underrated. Total group instruction is used daily in most classrooms and the majority of teachers follow a single textbook. Calculators are used frequently, but computers seldom. The Curriculum Guide is widely used as are materials from inservice programs. Teachers indicated several areas in which they desired further professional development.

Grade 12

Most grade 12 mathematics teachers have had teaching experience at both junior and senior high levels and teach courses in both the "00" and "01" streams, although fewer than one-third have taught one of the advanced option courses (Mathematics 305). About half of them teach mathematics full time and over 70% teach mathematics 60% time or more. Lecture and demonstration are the dominant instructional modes with little use of concrete materials or computers, although calculators are widely used. Homework is assigned much more frequently in Mathematics 300 than in Mathematics 301.

The strict election of option topics as outlined in the Guide in both courses is ignored in practice by teachers. Large proportions of teachers select parts of options, or in some cases no options, to teach. The majority of Mathematics 301 teachers felt that options should be retained, but one-half of Mathematics 300 teachers felt that their entire course should be compulsory, i.e., no options.

Even more strongly than in 1981, teachers expressed the view that less mathematics learning is taking place in the semester system than in the full-year system. They state that less teaching and learning time is available and that less content is covered.

Recommendations

The recommendations presented here are based upon a synthesis of the mathematics achievement data at four grade levels, the comparison test data, and the teacher survey data. They are not an exact repetition of the recommendations found in earlier chapters, but a synthesis of them. They have been organized by grade level and by the primary group or institution to which they are directed.

Grades 3 and 6

TO TEACHERS

That mathematics be taught at least the recommended number of minutes per day (i.e.,45).

That, where appropriate, the use of calculators be included in the mathematics program.

That problem solving receive increased emphasis at all levels.

That concrete materials be used in the introduction and maintenance of concepts and skill development.

That activity centres be included in the mathematics program to provide motivation as well as reinforcement.

That particular attention be paid to the transition from concrete manipulation to symbolic recording of students' work.

That more emphasis be given to the study of area, volume, and capacity, a topic important also for the science curriculum.

That continued attention be paid to the teaching of the SI metric system of measurement.

That estimation in numerical computation be taught as outlined in the Curriculum Guide.

That more attention be paid to estimation in numerical computation, rounding off, and the relationship between them.

That work with fractions, both conceptually and computationally, be given increased emphasis. [Grade 6]

That work with decimals, both conceptually and computationally, be emphasized.

TO SCHOOL DIVISIONS

That mathematics be taught at least the recommended number of minutes per day (i.e., 45).

That problem solving become an integral part of the school curriculum and of mathematics classroom activity at all levels.

That, where appropriate, the use of calculators be included in the school mathematics program and that explicit instruction be provided in the use of the calculator.

That teachers be provided with appropriate materials and professional development to teach measurement (length, area, volume, and capacity). [Grade 3]

That activity centres be included in the mathematics program to provide motivation as well as reinforcement.

That professional development be provided in the areas of need indicated by teachers: teaching problem solving, enrichment mathematics, using computers in teaching mathematics, manipulative materials, remediation in mathematics, teaching methods, using calculators (grade 6 only).

That consideration be given to professional development workshops in the metric system and in the teaching of concepts in elementary mathematics.

TO MANITOBA EDUCATION

That guidelines for appropriate calculator use be included in any future elementary mathematics curriculum guide.

That Manitoba Education support the premise that problem solving is an integral part of the curriculum and of mathematics classroom activity at all levels.

That professional development be provided in measurement concepts, problem solving and in the teaching of elementary mathematics concepts.

That professional development be provided in the areas of need indicated by teachers: teaching problem solving, enrichment mathematics, using computers in teaching mathematics, manipulative materials, remediation in mathematics, teaching methods, using calculators (grade 6 only).

TO FACULTIES OF EDUCATION

That problem solving techniques receive greater emphasis in teacher education programs.

That greater attention be focussed on the teaching of elementary school concepts.

Grade 9

TO TEACHERS

That problem solving strategies continue to be integrated into all parts of the curriculum.

That the topic of estimation be given renewed emphasis in the grade 9 program.

That repeating decimals be studied after the necessary algebraic concepts have been taught.

That work with computers and calculators become an integral part of the grade 9 school curriculum.

TO SCHOOL DIVISIONS

That problem solving strategies continue to be integrated into the school curriculum, and where appropriate, professional development be instituted.

That the topic of estimation be given renewed emphasis in the grade 9 program.

That work with computers and calculators become an integral part of the grade 9 school curriculum.

That inservice programs be organized on the appropriate use of the calculator and computer.

That inservice programs in the teaching of introductory algebra with emphasis on the use of concrete materials be organized.

That professional development be provided in the areas of need indicated by teachers: remediation, enrichment mathematics, teaching problem solving, using computers in teaching mathematics, teaching methods in mathematics.

That school division superintendents ensure that grade 9 mathematics teachers have an adequate professional and academic background for their teaching assignments.

TO MANITOBA EDUCATION

That problem solving strategies continue to be integrated into the curriculum, and where appropriate, professional development be instituted.

That consideration be given for the inclusion of the Algebra option as a core topic for all students.

That estimation be given greater emphasis in the curriculum.

That inservice programs in the teaching of introductory algebra with emphasis on the use of concrete materials be organized.

That work with computers and calculators become an integral part of the grade 9 curriculum.

That inservice programs be organized on the appropriate use of the calculator and computer.

That professional development be provided in the areas of need indicated by teachers: remediation, enrichment mathematics, teaching problem solving, using computers in teaching mathematics, teaching methods in mathematics.

That Manitoba Education encourage school divisions to assign teachers with an adequate background for their teaching assignments.

That Manitoba Education encourage the introduction of upgrading or refresher courses for junior high mathematics teachers.

That consideration be given to modifying the curriculum guide for grade 9, to include the topics noted in these recommendations.

TO FACULTIES OF EDUCATION

That faculties of education ensure that their mathematics education students be familiar with:

- the teaching of problem solving
- the use of manipulative materials in the teaching of algebra
- the appropriate use of calculators
- estimation concepts.

That faculties of education consider the introduction of upgrading or refresher courses for junior high teachers of mathematics.

Grade 12

TO TEACHERS

That every effort be made to increase students' mathematical vocabulary by constantly using correct and appropriate mathematical notation and terminology.

That the use of transformations as a foundational concept in the development of relations and functions be emphasized throughout Mathematics 300.

TO SCHOOL DIVISIONS

That school divisions determine and provide for the professional development needs of their high school mathematics teachers.

That the counselling of students in Mathematics 300 be examined to determine the reasons students are taking this course.

That school divisions ensure that sufficient time is available so that teachers are able to teach the entire mathematics curriculum.

School division superintendents should ensure that schools do not grant Mathematics 301 credits to students who have been enrolled in Mathematics 300 and for some reason will not be issued Mathematics 300 credits.

TO MANITOBA EDUCATION

That the factors that motivate students to select Mathematics 300 be examined by Manitoba Education.

That the core/option format of Mathematics 300 and the designation of particular topics as "options" be examined.

That Mathematics 301 option topics be reassessed to determine whether this part of the curriculum should be revised.

That Manitoba Education develops and maintains the Student Academic Record System in such a way that analysis over time can be made on numbers of students enrolled and numbers of students who have successfully completed individual courses.

That Manitoba Education studies the issue of low performance at the Mathematics 300 level and implement strategies to redress this problem.

That Manitoba Education reviews the issue of the low general arithmetic skill levels of Manitoba high school students and implement appropriate strategies to redress this problem.

TO FACULTIES OF EDUCATION

That faculties of education ensure that their student teachers are familiar with the variety of test item construction techniques.

That Faculty of Education students be encouraged to emphasize the importance of students' mathematical vocabulary in their teaching.

That the use of transformations as a foundational concept in the development of relations and functions be emphasized.

TO POSTSECONDARY INSTITUTIONS

That consideration be given to making Mathematics 301 the mathematics admission requirement to postsecondary programs not requiring the specific content of Mathematics 300.